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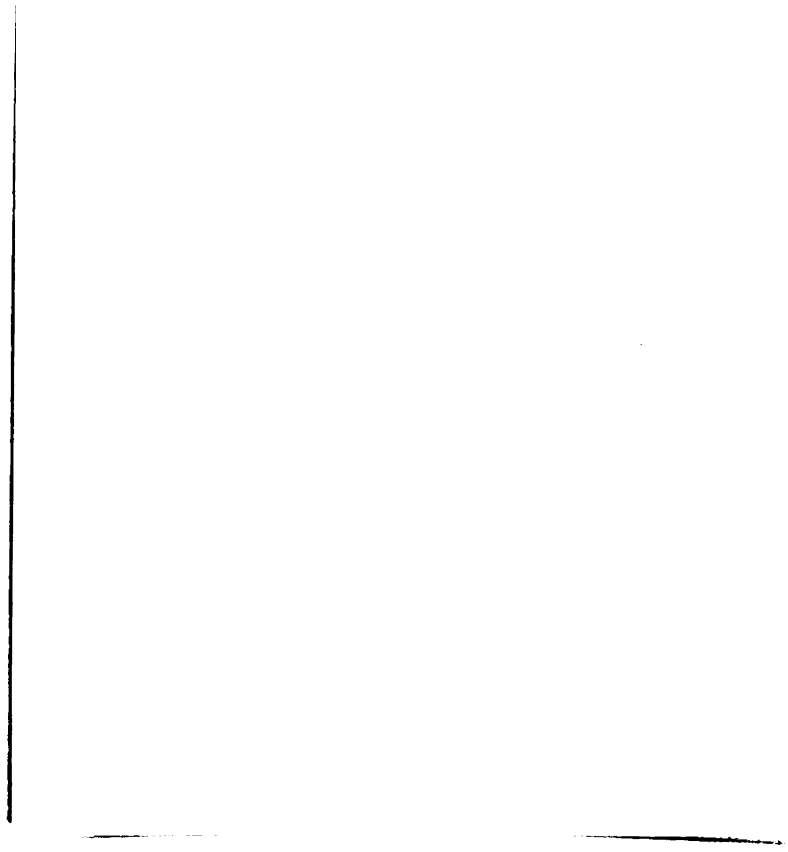

THE SYNTHESIS OF DERIVATIVES OF 3-AMINO-4-H,1,2,4-TRIAZOLE

BY

Emerson A. Cooper

A THESIS

Submitted to the School for Advanced Graduate Studies of
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Chemistry

1959

To Marjorie, Roslyn and Stephen

A C K N O W L E D G M E N T

I am indebted to Dr. Robert M. Herbst for his generous and invaluable counsel. His sage suggestions in the course of this investigation were indeed a source of much encouragement and inspiration. I am also thankful for the support given me by Oakwood College and the Danforth Foundation.

THE SYNTHESIS OF DERIVATIVES OF 3-AMINO-4-H,1,2,4-TRIAZOLE

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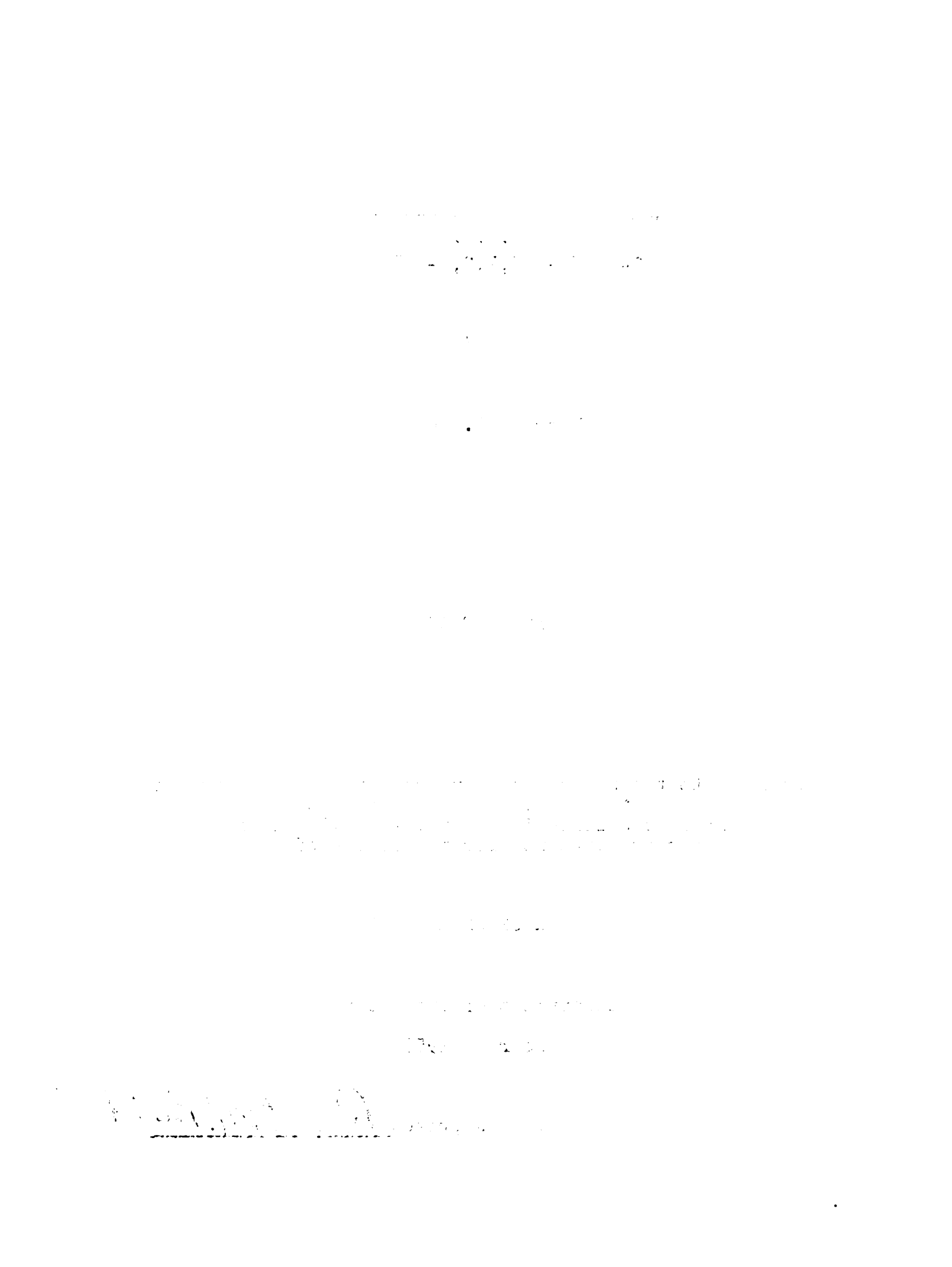

It has been observed that rearrangements sometimes occur in certain heterocyclic systems containing the N-C-N arrangement where one of the nitrogens is an amino group. Dimroth (1) has described the thermal rearrangement of a number of 1-phenyl-5-amino-, and 1-phenyl-5-methylamino-1,2,3-triazoles to 5-phenylamino-, and 1-methyl-5-phenylamino-1,2,3-triazoles. Lieber et al (2,3) have investigated the rearrangement of 5-amino-1,2,3-triazoles. The rearrangement of 5-alkylaminotetrazoles to 1-alkyl-5-aminotetrazoles has also been studied (4).

The original purpose of this investigation was to determine whether 3-amino-4-phenyl-1,2,4-triazole and its homologs would undergo a similar rearrangement. After preliminary experimentation indicated the absence of such rearrangement in the 1,2,4-triazole series, attention was then directed to the synthesis of three different series of compounds having varied substituents in the fifth position of 3-amino-4-phenyl-4-H,1,2,4-triazole.

3-Amino-4-H,1,2,4-triazole is presently of considerable interest because of its remarkable effect on the physiological processes of plants and animals. It is able to inhibit the synthesis of chlorophylls and carotenoids in plants (5); it reduces the level of hepatic and renal catalase activity in rats thus producing an

effect similar to that observed in animals having malignant growth (6); and it is also capable of lowering the activity of δ-aminolevulinic acid dehydrase, an enzyme that catalyzes the conversion of δ-aminolevulinic acid to porphobilinogen (6). The last effect is also produced by tumors.

Since studies relating phytotoxicity to chemical structure indicate the importance of chloro, methyl, methoxy and phenoxy groups on herbicides (7), it was decided to prepare a representative group of substituted phenoxymethyltriazoles and some thiophenoxymethyltriazoles.

A number of dialkylaminomethyltriazoles was also prepared since the presence of two different heterocyclic nuclei in some, and the existence of two basic centers in all could possibly produce anesthetic action as well as some other useful physiological effect. It is of interest to note that 3-ethyl-4-cyclohexyl-1,2,4-triazole is similar to adrenaline in some of its actions on the body. It has been found to stimulate the heart and respiratory center (8).

The starting material for these syntheses, phenylaminoguanidinium bisulfate, was first prepared in the course of this work. This compound was allowed to react with a number of aliphatic acids (formic, acetic, glycolic, lactic and phenoxyacetic acid) to form the corresponding 3-amino-4-phenyl-5-alkyl-1,2,4-triasoles.

A procedure was perfected for the conversion of 3-amino-4-phenyl-5-hydroxymethyl-1,2,4-triazole to the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in good yield.

The 5-dialkylaminomethyltriazoles were prepared by allowing the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole to react with an excess of each of the following amines: piperidine, morpholine, pyrrolidine, dimethylamine, diethylamine, diallylamine, di-n-propylamine, di-isopropylamine, di-n-butylamine and di-isobutylamine.

The 5-phenoxymethyl-, and the 5-thiophenoxymethyltriazoles were prepared by allowing the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole to react with an excess of the sodium salt of each of the following phenols and thiophenols: phenol, p-bromophenol, p-chlorophenol, p-methoxyphenol, p-cresol, o-cresol, m-cresol, thiophenol and p-chlorothiophenol.

Phenylthiourea derivatives of most of these new aminotriazoles were prepared. In a few cases, a number of the hydrochlorides and acetyl derivatives were prepared.

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(1) Dimroth, Ann. Chem., 364, 183 (1909)

(2) Lieber, E., Chao, T.S. and Rao, C.N.R., J. Org. Chem., 22, 654 (1957)

(3) Lieber, E., Rao, C.N.R. and Chao, T. S., J. Am. Chem. Soc., 79, 5962 (1957)

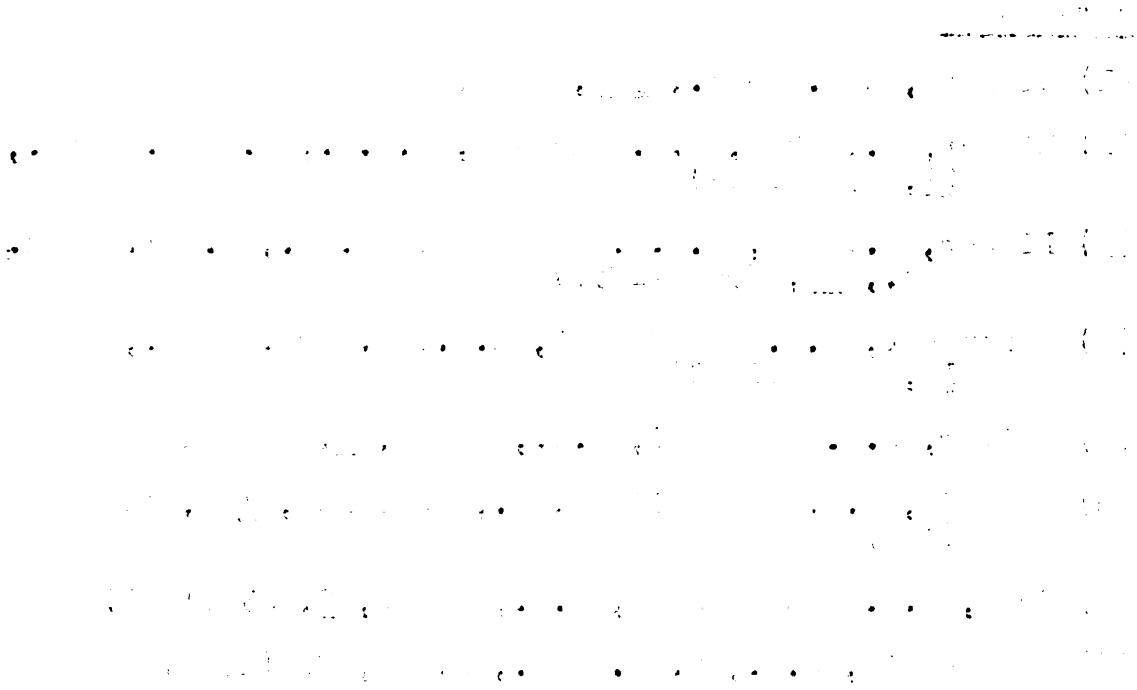
(4) Garbrecht, W.L. and Herbst, R.M., J. Org. Chem., 18, 1269 (1953)

(5) Miller, C.S. and Hall, W.C., Weeds, 5, 304 (1957)

(6) Tschudy, D.P. and Collins, A., Science, 126, 168 (1957)

(7) Shaw, W.A. and Swanson, C.R., Weeds, 2, 43 (1953)

(8) Lewenstein, M.J., U. S. Pat., 2,683,106 (1954)



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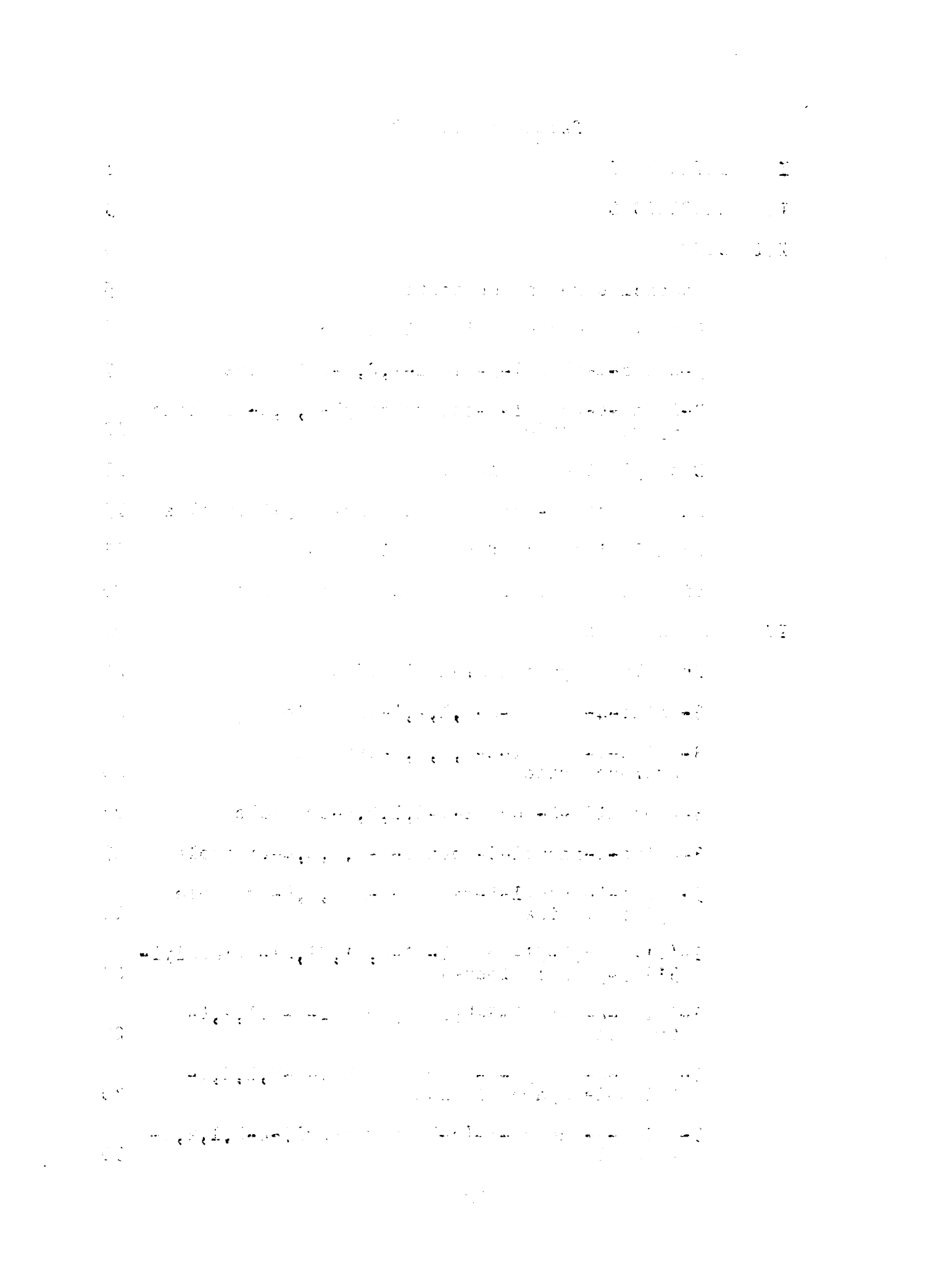

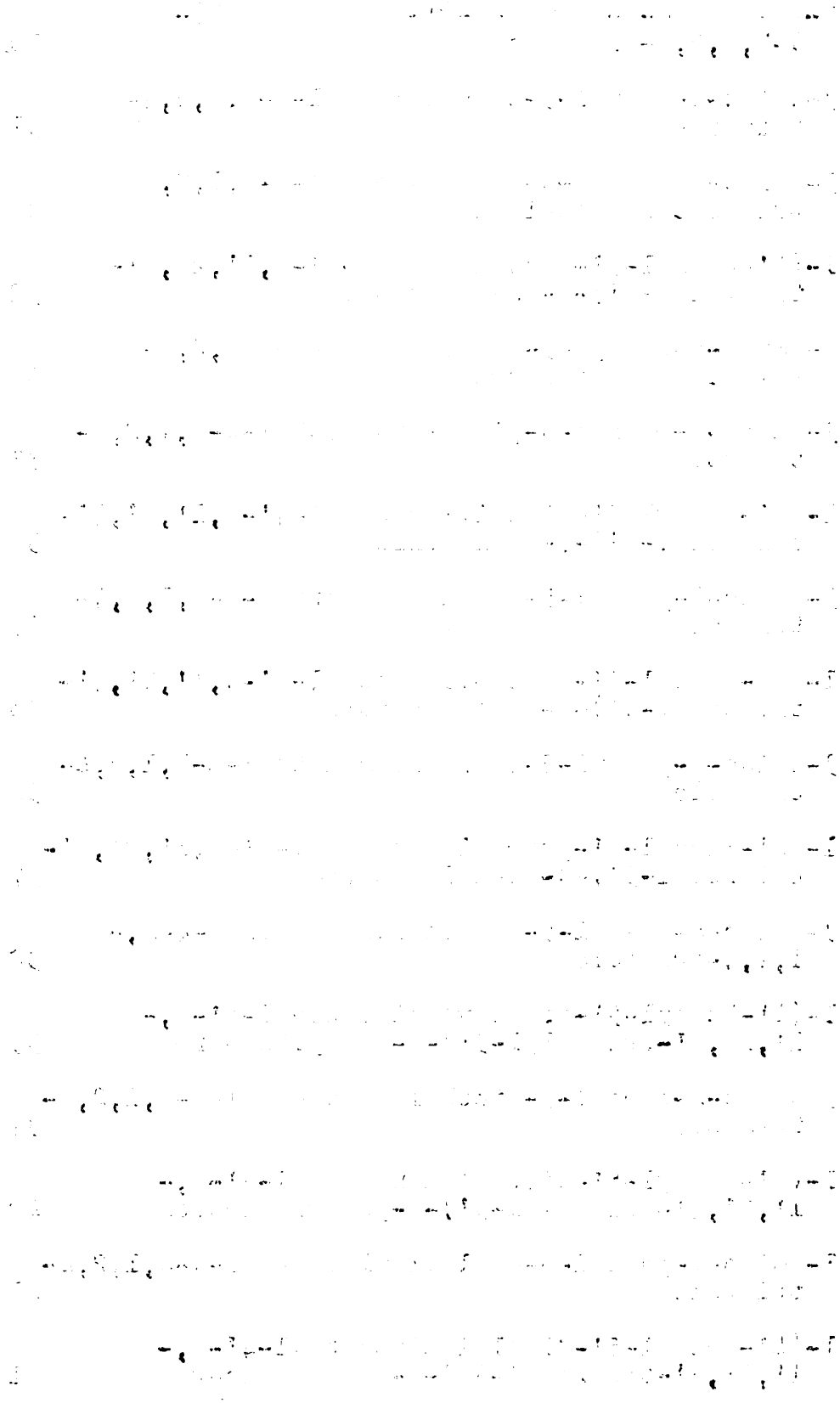

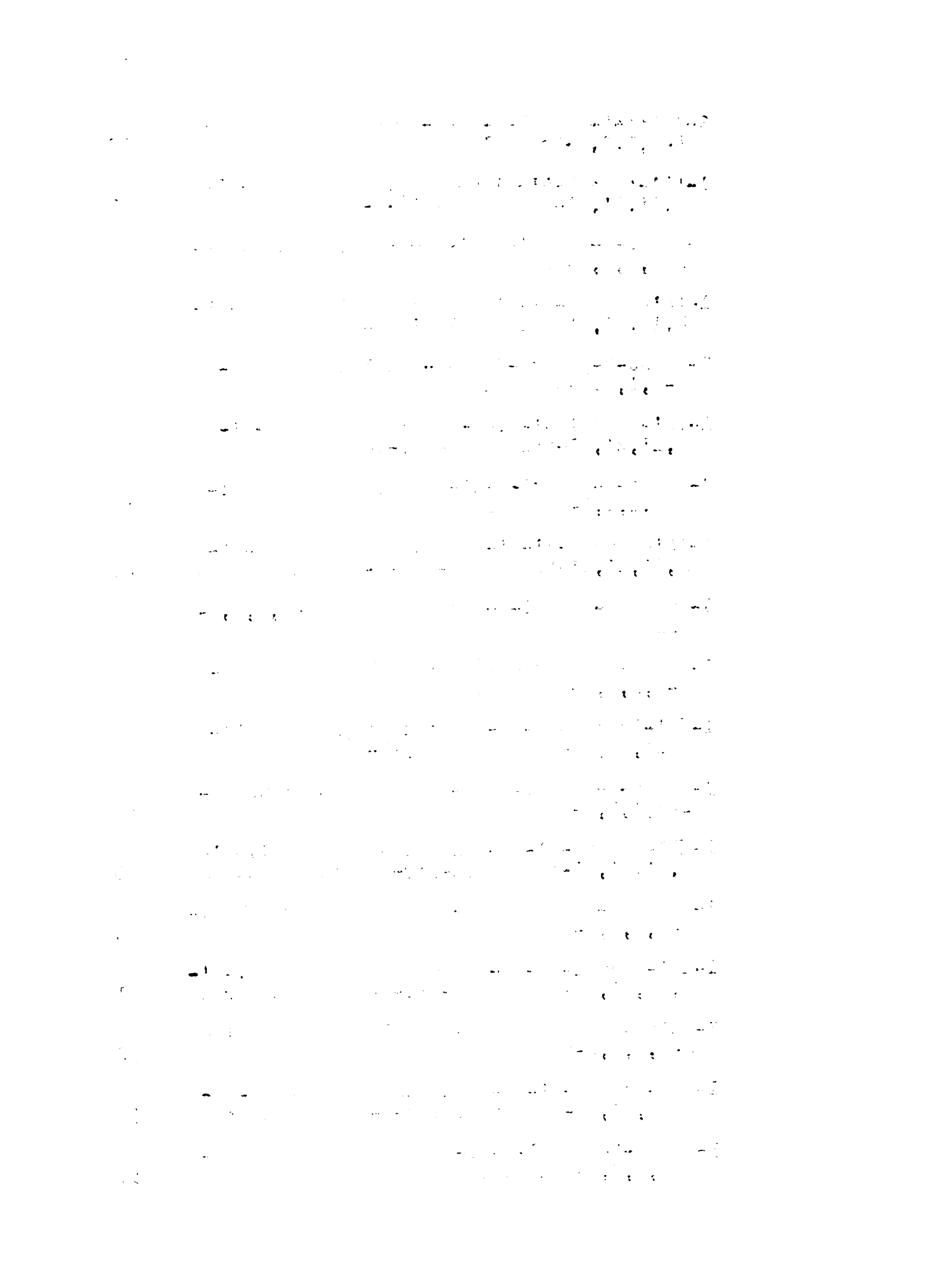

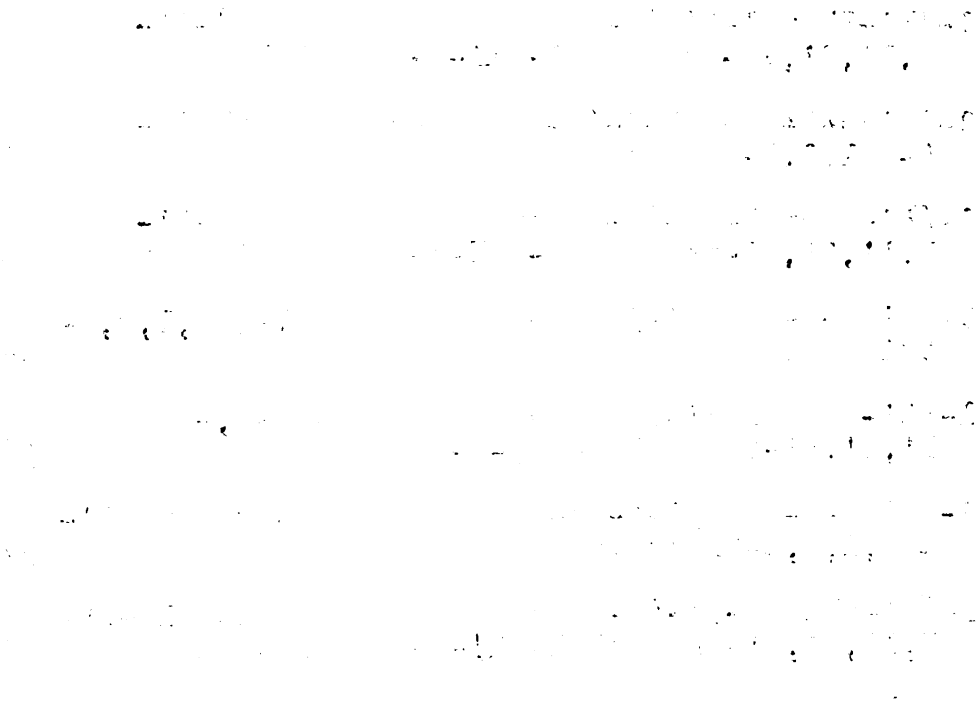

Introduction

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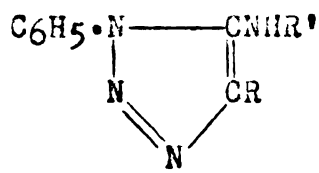
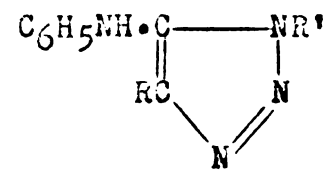


I



II

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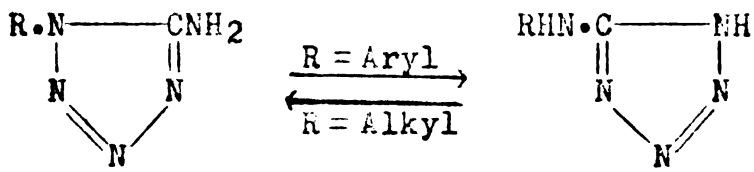

The original purpose of this investigation was to determine whether 3-amino-4-phenyl-1,2,4-triazole and its homologs would undergo a similar rearrangement. After preliminary experimentation indicated the absence of such rearrangement in the 1,2,4-triazole series, attention was then directed to the synthesis of three different series

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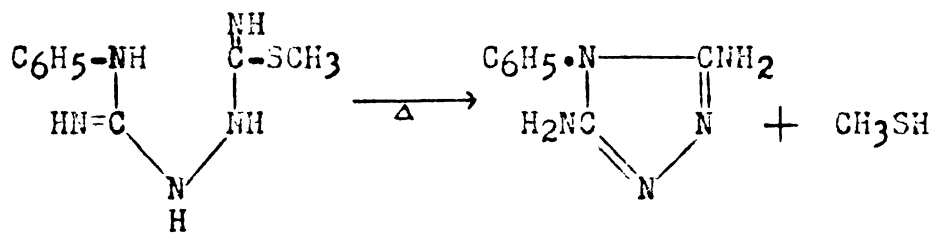
Historical

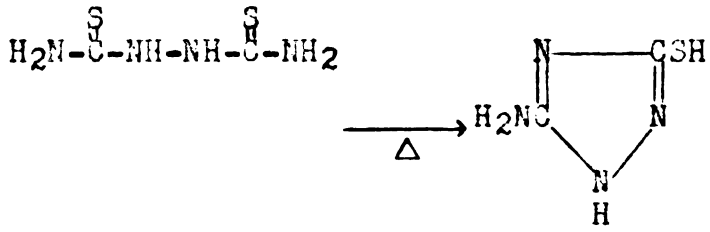
The first derivatives of 1,2,4-triazole were prepared by Bladin (9) in 1885. Six years later, in 1891, Bladin (10) and Andreocci (11), working independently, synthesized the parent compound, 1,2,4-triazole. In the same year, Thiele (12) discovered the first general method of preparing derivatives of 3-amino-1,2,4-triazole. He found that aminoguanidine reacts with acetic acid to form 3-amino-5-methyl-1,2,4-triazole. Later, Thiele and Manchot (13) showed the general nature of this reaction by preparing 3-amino-1,2,4-triazole from aminoguanidine and formic acid; and 3-amino-1,2,4-triazole-5-carboxylic acid from aminoguanidine and oxalic acid. This method has been termed the dehydration of acyl derivatives of aminoguanidines.

Some other methods that have been employed in the synthesis of derivatives of 3-amino-1,2,4-triazole are summarized below:

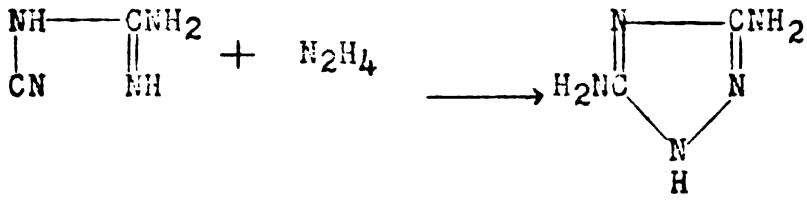
(1) The elimination of methylmercaptan from an S-methyl ether of phenylguanylthiosemicarbazide (14):



(2) The fusion of a diamide of hydrazine-N:N:'-dithiodicarboxylic acid (15):



(3) Reaction of dicyandiamide with hydrazine (16):

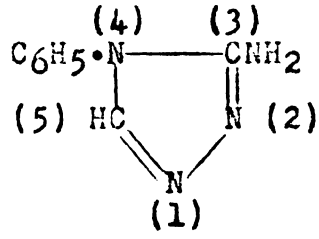


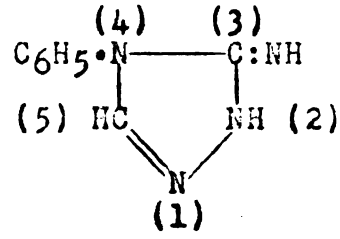
A number of reviews on the chemistry of 1,2,4-triazoles are available (17,18,19,20).

Discussion

Nomenclature and Properties

The nomenclature used in the discussion of derivatives of 3-amino-4-phenyl-4-H,1,2,4-triazole in this thesis, is based upon the following formulas for this compound:





A survey of the literature shows that aminotriazoles exhibit many of the properties of aromatic amines. However, they also react both as weak bases and weak acids as is shown by the formation of hydrochlorides, nitrates, and picrates on the one hand, and of metal salts on the other. They are quite stable toward oxidizing agents, forming only azo derivatives. They diazotize to form diazonium salts which can couple with phenols and amines. These diazonium salts can be reduced to give C-hydrazino-1,2,4-triazoles and can react with hydrogen halides to form C-halogeno-1,2,4-triazoles (21). C-methyl groups can be oxidized to carboxyl groups, and N-phenyl groups can be oxidatively removed after nitration and reduction. The amino group can also react with aldehydes to form condensation products (22).

Phenylaminoguanidinium Bisulfate

Phenylaminoguanidinium bisulfate was an important intermediate in the synthesis of various derivatives of 3-amino-4-phenyl-1,2,4-triazole. It was prepared from S-methyl phenylisothiourea hydriodide by the method used by Kirsten and Smith (23) to prepare α-alkyl-δ-aminoguanidines. Kirsten and Smith were unsuccessful in obtaining phenylaminoguanidine, but Finnegan et al (24) have prepared the hydriodide. The bisulfate was first prepared in the course of this investigation since the hydriodide was found to be unsuitable for the synthesis of 3-amino-1,2,4-triazoles. The following sequence of reactions illustrates the method:

$$C_6H_5\text{-}NH\text{-}\overset{S}{\overset{\|}{C}}\text{-}NH_2 + CH_3I \longrightarrow C_6H_5\text{-}NH\text{-}\overset{SCH_3}{\overset{|}{C}}\text{:}NH_2^+\ I^-$$

$$C_6H_5\text{-}NH\text{-}\overset{SCH_3}{\overset{|}{C}}\text{:}NH_2^+\ I^- + N_2H_4 \longrightarrow C_6H_5\text{-}NH\text{-}\overset{NH_2^+}{\overset{|}{C}}\text{-}NH\text{-}NH_2\ I^-$$

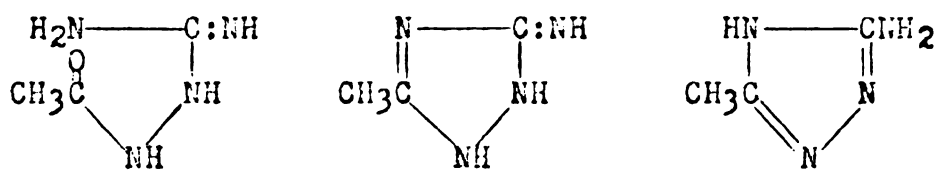
$$C_6H_5\text{-}NH\text{-}\overset{NH_2^+}{\overset{|}{C}}\text{-}NH\text{-}NH_2\ I^- + Ag_2SO_4 + H_2SO_4 \longrightarrow C_6H_5\text{-}NH\text{-}\overset{NH_2^+}{\overset{|}{C}}\text{-}NH\text{-}NH_2\ HSO_4^-$$

The method of Finnegan, Henry and Lieber (24) was employed in preparing the S-methyl phenylisothiourea hydriodide. An alcoholic solution of the isothiourea was obtained by treating a slurry of phenylthiourea in alcohol at 5° C. with methyl iodide and then permitting the reaction to go to completion at room temperature. The second reaction was carried out without isolating the isothiourea.

In this reaction, the S-methyl phenylisothiourea reacts with hydrazine to form phenylaminoguanidinium iodide and methyl mercaptan. In the final reaction, the phenylaminoguanidinium iodide is converted to the bisulfate by a metathetical reaction with silver sulfate in the presence of sulfuric acid.

3-Amino-4-phenyl-5-alkyl-1,2,4-triazoles

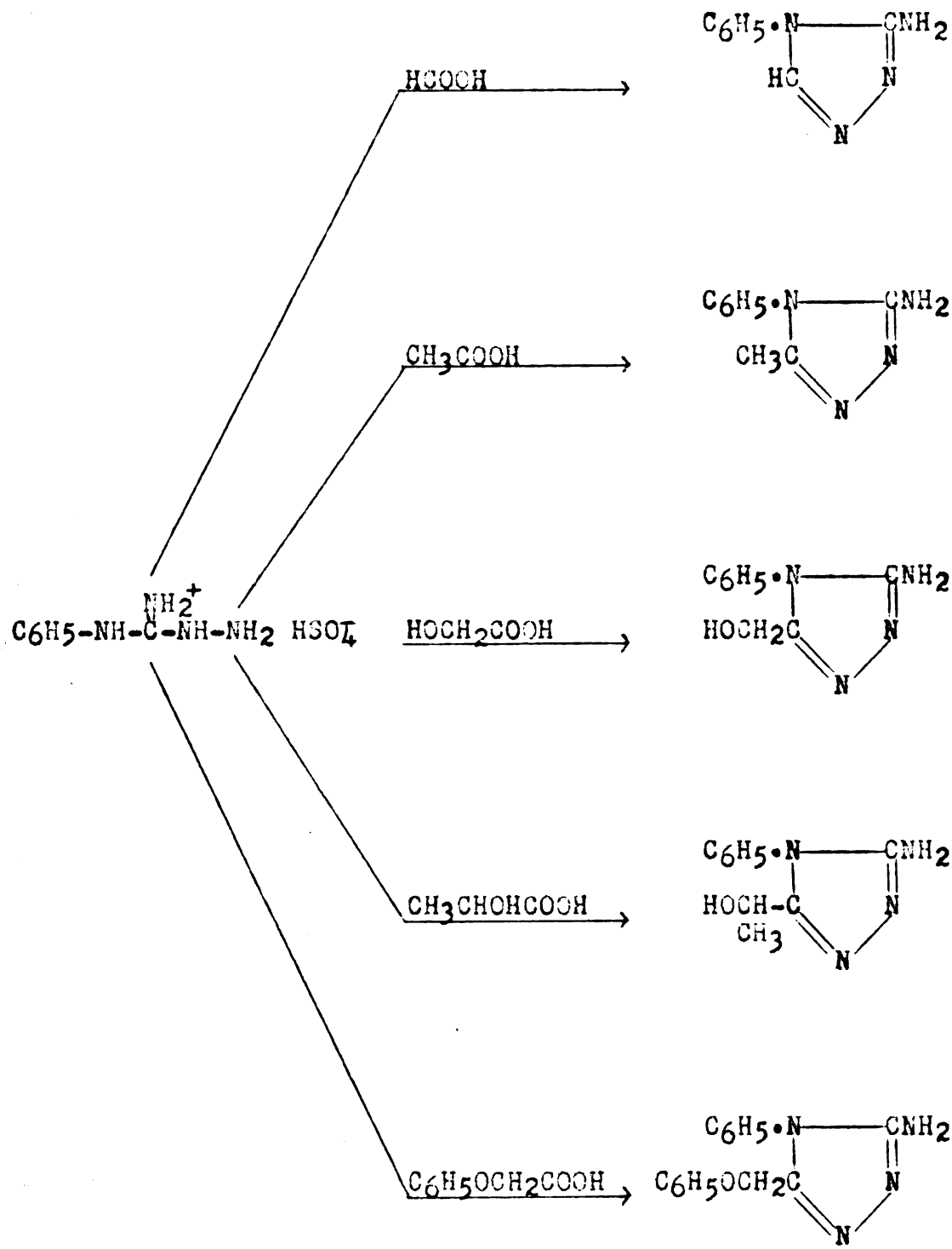
The method used in the synthesis of these compounds is basically the one discovered by Thiele (12) in 1891. He observed that aminoguanidine reacts with acetic acid to form acetylaminoguanidine which on warming or treatment with alkali loses a molecule of water and cyclizes to form an inner anhydro base:



Thiele and Heidenreich (25) found that this substance had the properties of an acid and that on oxidation an azomethyltriazole was formed; later work showed that an amino group capable of diazotization was present (21). Thiele and Manchot (13) showed the general nature of this reaction by preparing 3-amino-1,2,4-triazole from aminoguanidine and formic acid, and 3-amino-1,2,4-triazole-5-carboxylic acid from aminoguanidine and oxalic acid.

Reilly and Madden (26) have prepared the corresponding 5-ethyl-, 5-isopropyl-, and 5-isobutylaminotriazoles; and Reilly and Drumm (22) have prepared the 3-amino-5-n-propyl-1,2,4-triazole.

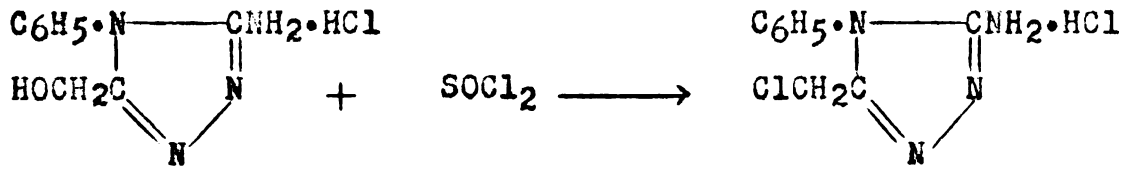
By the reaction of phenylaminoguanidinium bisulfate with an appropriate aliphatic acid or its derivative, it was possible to prepare 3-amino-4-phenyl-1,2,4-triazole and a number of 3-amino-4-phenyl-5-alkyl-1,2,4-triazoles. These syntheses are illustrated on the next page:


HCOOH
CH3COOH
HOCH2COOH
CH3CHOHCOOH
C6H5OCH2COOH
C6H5-NH-C(NH2+)-NH-NH2 HSO4-
C6H5·N
CNH2
HC
N
CH3C
HOCH2C
HOCH-C
CH3
C6H5OCH2C

3-Amino-4-phenyl-5-chloromethyl-1,2,4-triazole Hydrochloride

Some difficulties were encountered in the preparation of this important intermediate. Several attempts to synthesize it by the reaction of phenylaminoguanidinium bisulfate and chloroacetic acid (Thiele's method) were fruitless. Bloom and Day (27) had succeeded in preparing 2-chloromethylbenzimidazole in good yields by using the method of Phillips (28). They heated o-phenylenediamine with chloroacetic acid in 4N hydrochloric acid for forty-five minutes, allowed the mixture to stand overnight at room temperature and then neutralized it in the cold with 6N ammonium hydroxide. When phenylaminoguanidinium bisulfate and chloroacetic acid were allowed to react under comparable conditions, 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole was obtained in poor yield. It was finally decided to attempt to prepare this compound from the corresponding hydroxymethyltriazole. After several experiments, a procedure was worked out for the smooth conversion of the hydroxymethyltriazole to the chloromethyltriazole in good yield.

The hydrochloride of 3-amino-4-phenyl-5-hydroxymethyl-1,2,4-triazole was prepared and then treated with an excess of thionyl chloride in chloroform. After refluxing for ten hours and allowing the mixture to stand overnight, the chloromethyltriazole could be isolated in good yield.



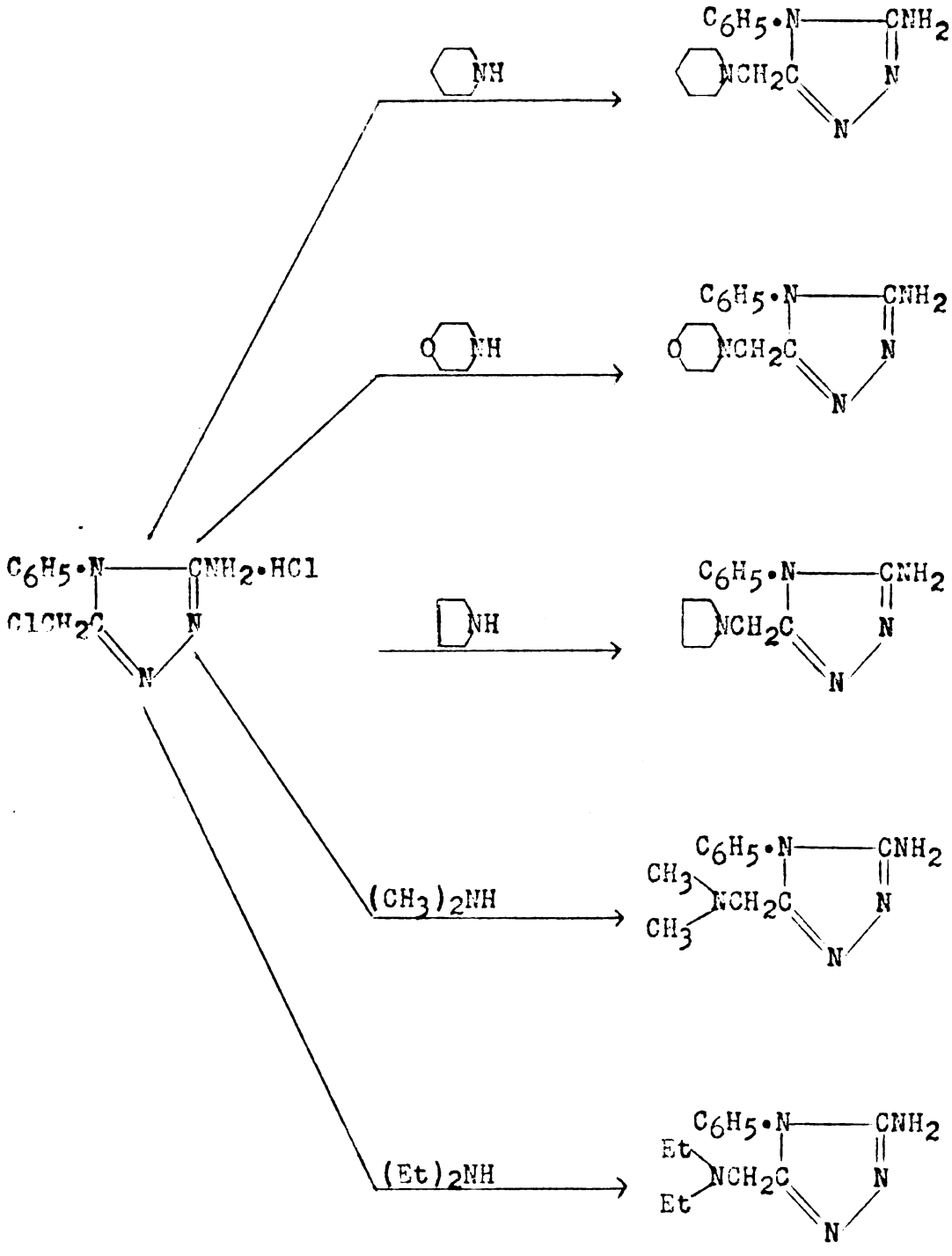
This intermediate was employed in the synthesis of the various dialkylaminomethyl- and phenoxymethyltriazoles.

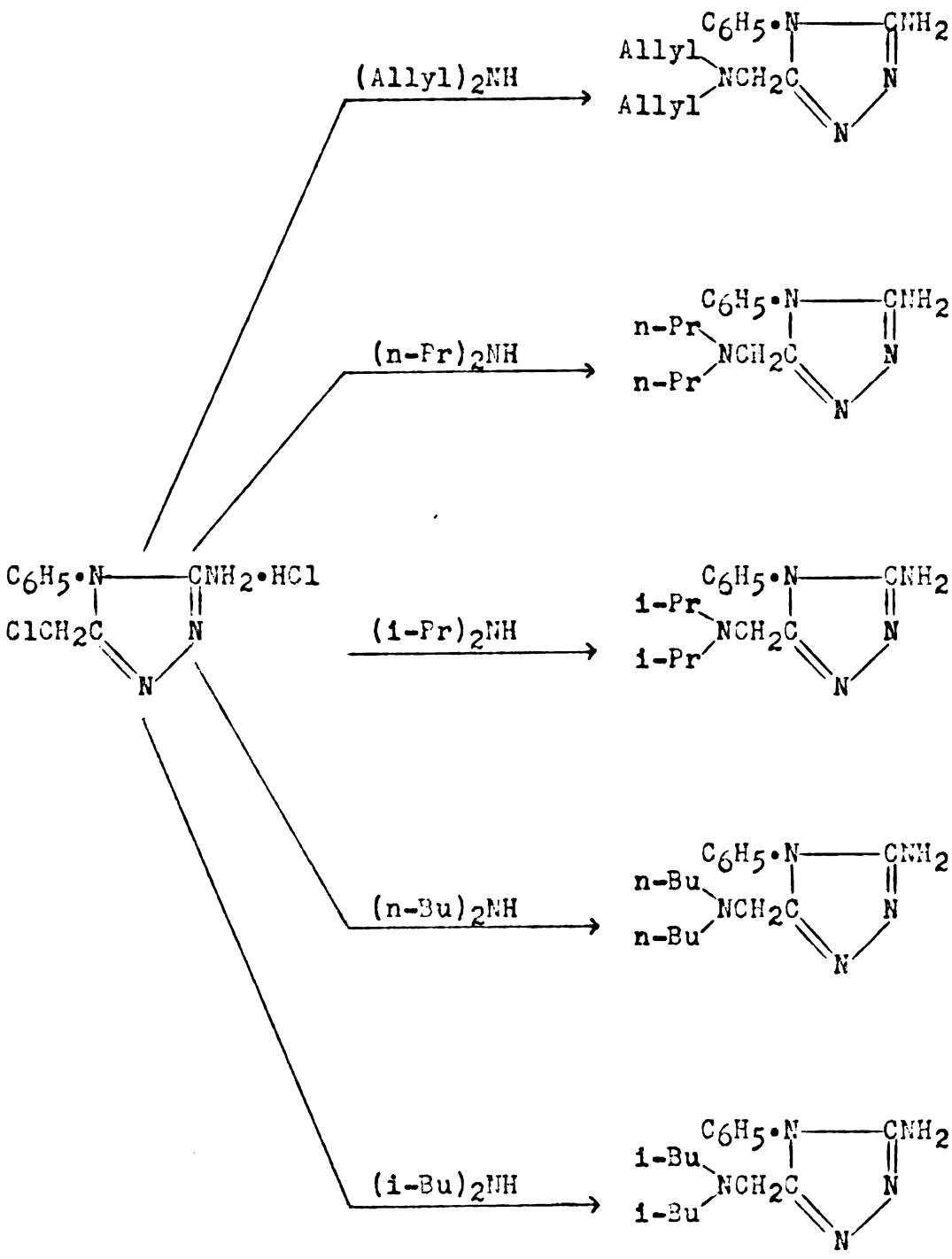
Dialkylaminomethyltriazoles

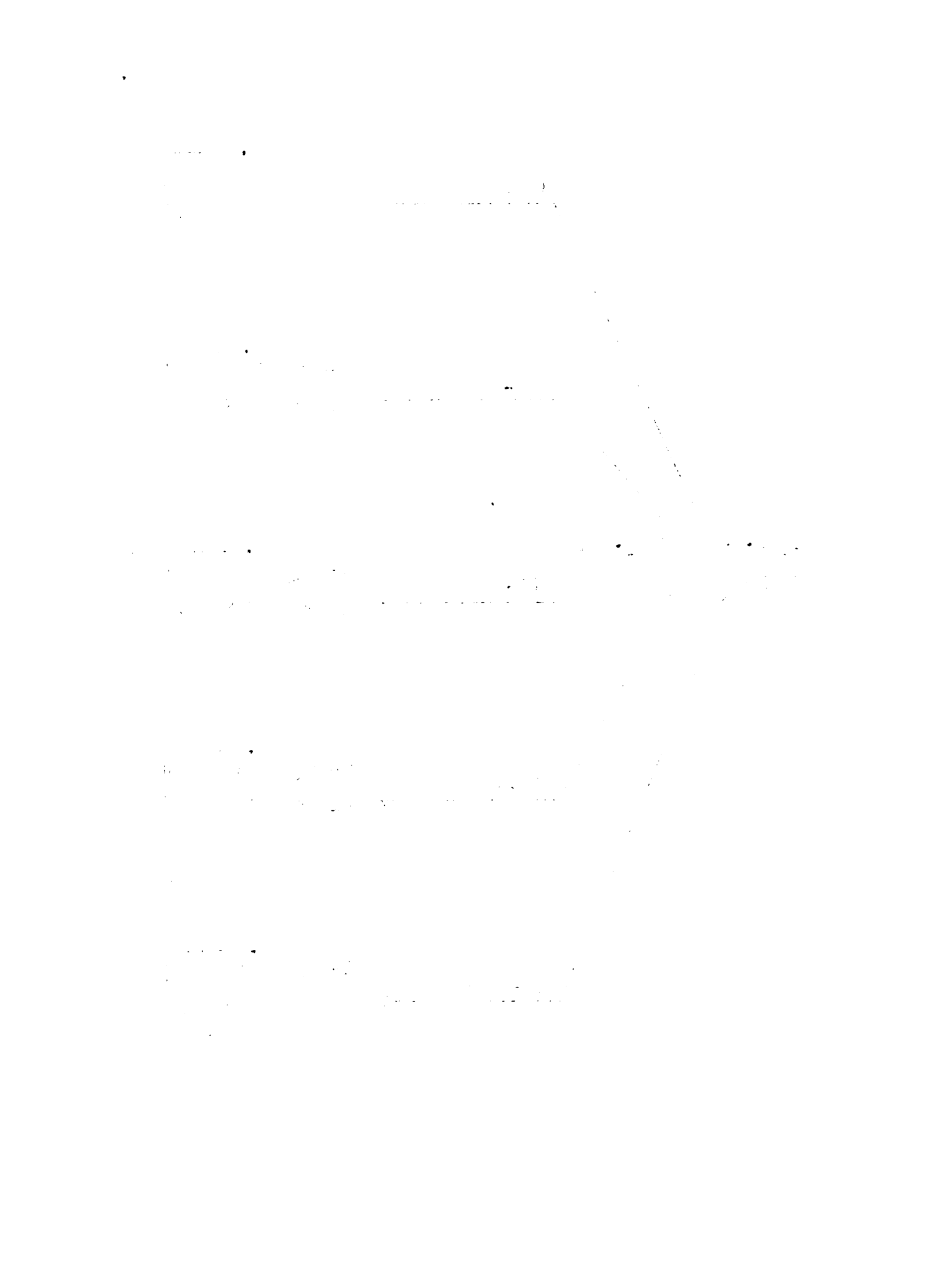
The presence of both a reactive halogen and a moderately reactive amino group in the molecule of the intermediate was a source of some difficulty in the synthesis of these compounds.

In preparing these compounds, an alcoholic solution of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole was treated with the calculated amount of a secondary amine necessary to (1) liberate the amino group of the chloromethyltriazole, (2) react with the reactive halogen and (3) combine with the hydrogen chloride produced in the course of the reaction. Since the amino group of the secondary amine is much more basic than the amino group of the triazole, these reactions were allowed to proceed for a day or more at room temperature. These conditions were found to be most favorable for the reaction of the amino group of the secondary amine, and least favorable for the reaction of the amino group of the aminotriazole.

Sufficient sodium hydroxide was then added to liberate the excess secondary amine from its hydrochloride. The excess secondary amine was then removed along with the solvent by evaporating to dryness under reduced pressure. The product was then extracted from the sodium chloride with toluene. The best yields were obtained from those reactions involving the more basic secondary amines. These syntheses are illustrated on the following two pages:


C6H5•N
CNH2•HCl
ClCH2C
N
NH
NCH2C
(CH3)2NH
CH3
(Et)2NH
Et

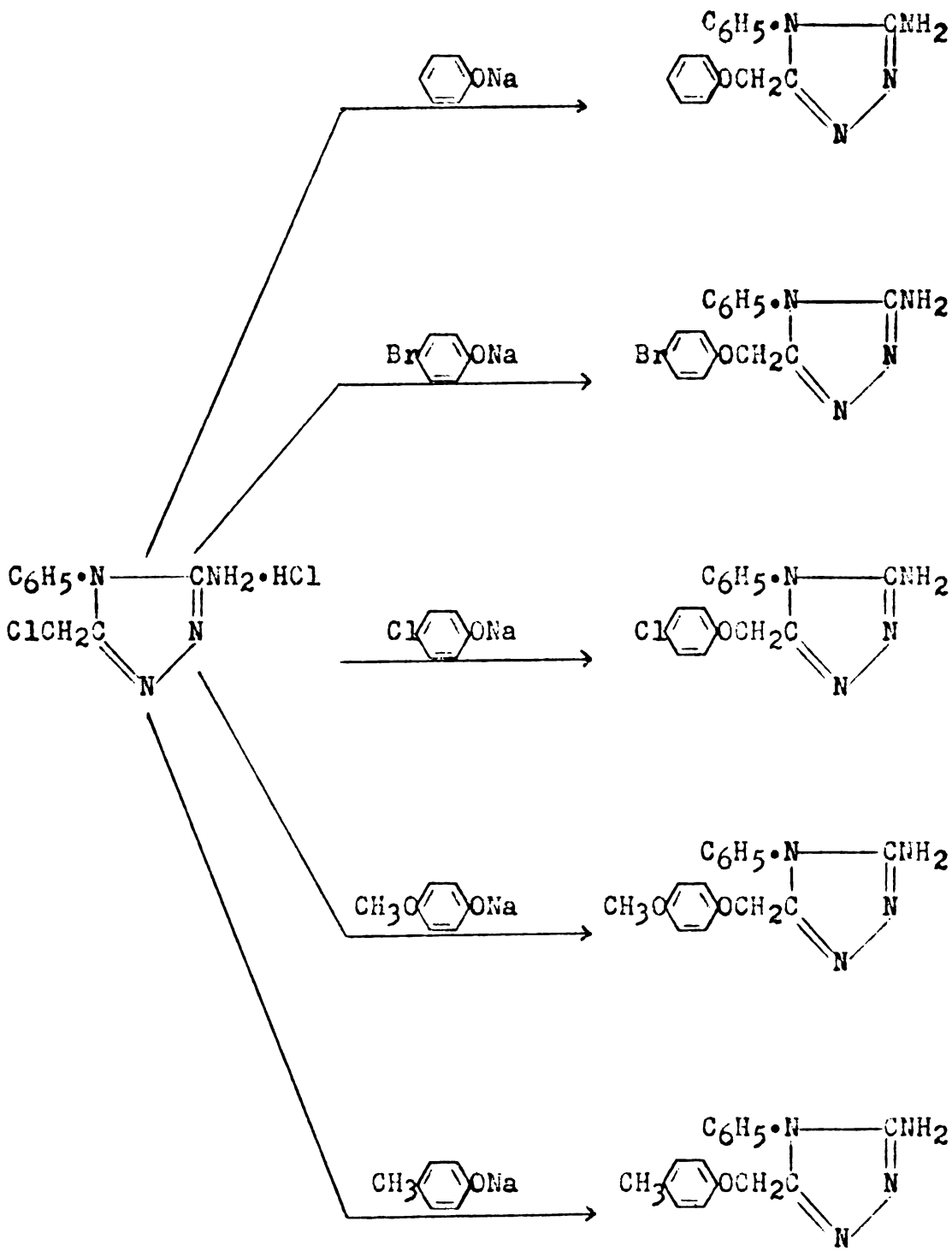

C6H5•N
CNH2•HCl
ClCH2C
N
(Allyl)2NH
(n-Pr)2NH
(i-Pr)2NH
(n-Bu)2NH
(i-Bu)2NH
Allyl
n-Pr
i-Pr
n-Bu
i-Bu
NCH2C



Phenoxymethyl- and thiophenoxymethyltriazoles

The same conditions employed in the synthesis of the dialkylaminomethyltriazoles were used in order to minimize the reaction of the amino group of the chloromethyltriazole.

In preparing the phenoxymethyltriazoles, an alcoholic solution of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole was treated with a solution containing at least the stoichiometric amount of the appropriately substituted sodium phenoxide in alcohol. These reactions were then allowed to proceed for a day or more at room temperature. In the case of those reactions involving sodium phenoxides with electron-repelling groups substituted in the ortho or para positions, precipitation of the product usually began promptly after the initial reaction had subsided. The best yields were usually obtained in these reactions. In those reactions in which no product precipitated at the end of the reaction time, the mixture was heated on the steam bath for about one hour to ensure completion of the reaction. Water was then added to the cooled solution to precipitate the product. These syntheses are illustrated on the following pages:


C6H5•N
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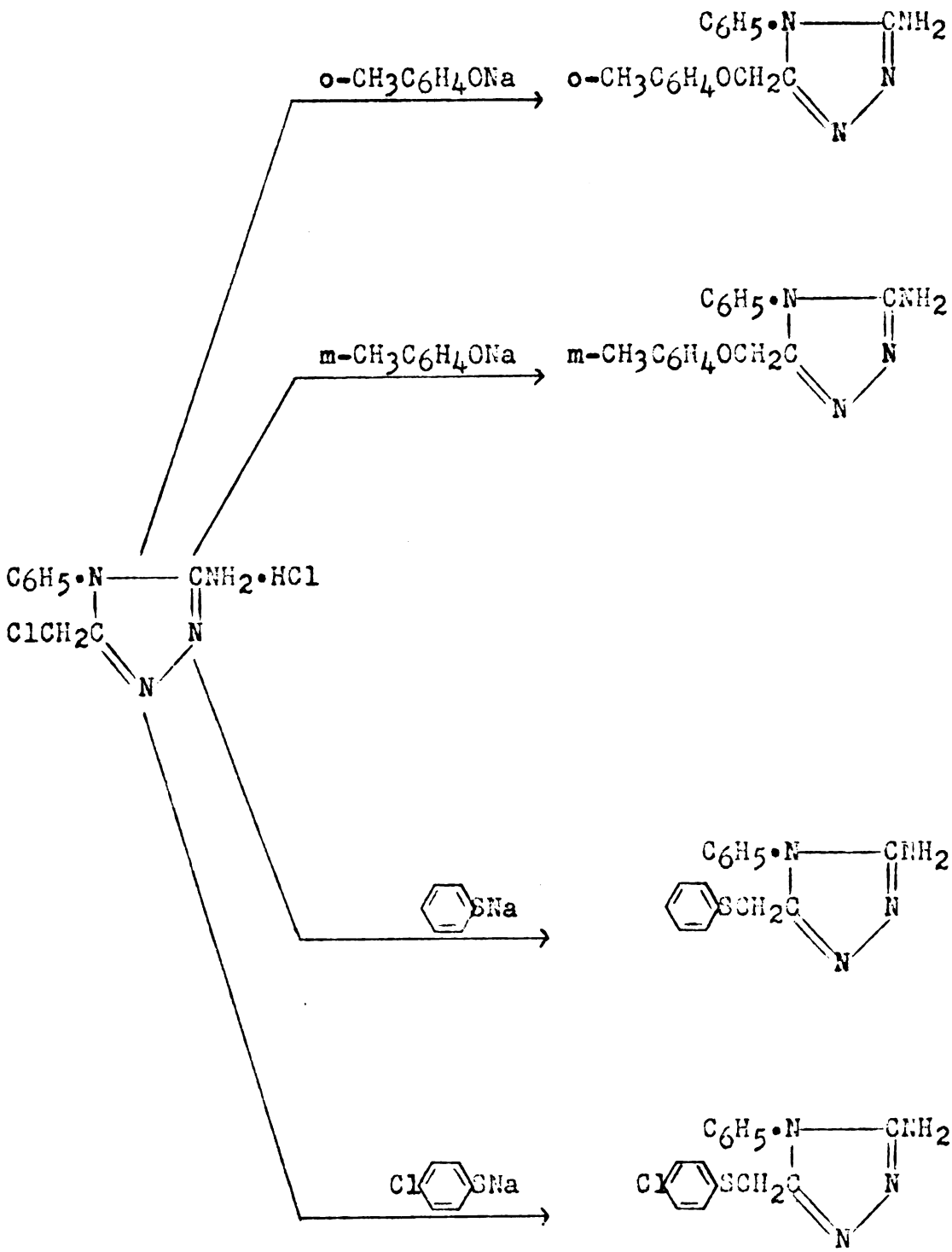
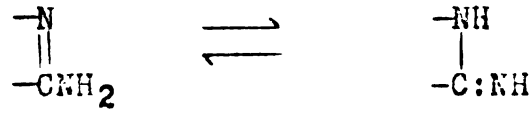
ClCH2C
N
ONa
OCH2C
Br
Cl
CH3O
CH3


o-CH3C6H4ONa
m-CH3C6H4ONa
C6H5•N
CNH2•HCl
ClCH2C
N
SNa
Cl
SCH2C

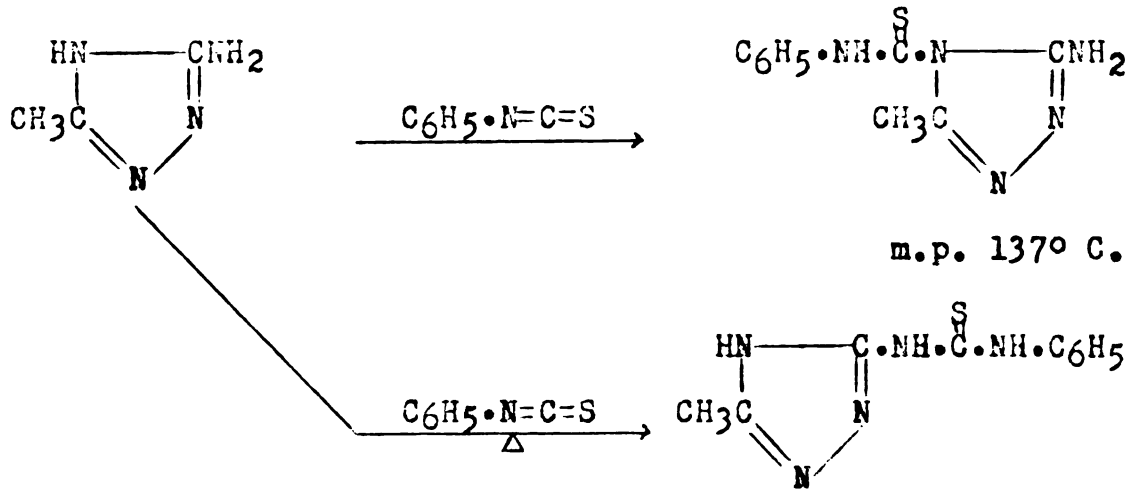
Phenylthioureas of Aminotriazoles

Fromm (29) and other investigators were the first to note the remarkable fact that the phenylthioureas derived from a number of heterocyclic compounds containing the group:



occurred in two isomeric forms. The low melting isomer is obtained by allowing the heterocyclic amine to react with phenylisothiocyanate at room temperature. The higher melting isomer is formed when the reaction is carried out at a higher temperature. The low melting labile isomer can be converted into the high melting stable form by heating it above its melting point. The reverse of this change is not observed. Fromm suggested that the labile isomer is derived from a secondary amine and the stable form from a primary amine.

Fantl and Silbermann (30) have studied the behavior of aminotriazoles toward phenylisothiocyanate. They found that 3-amino-5-methyl-1,2,4-triazole reacted with phenylisothiocyanate in the cold to produce a substance melting at 137° C., which solidified at 140° C. and then melted at 197° C. They also obtained the higher melting compound directly by heating the reactants in a high boiling solvent (n-amyl alcohol) for two hours. They assigned the following formulas to their two products:



m.p. 137° C.

m.p. 197° C.

Further studies showed that the presence of isomerism among the phenylthioureas of aminotriazoles was not a general occurrence since 2-phenyl-3-allylamino-1,2,4-triazole reacted with phenylisothiocyanate to yield only one stable phenylthiourea.

In preparing the phenylthioureas of the aminotriazoles which were synthesized in the course of this study, the author did not observe the presence of isomerism.

Biological Properties of Aminotriazoles

Interest in the study of the biological properties of aminotriazoles was strongly stimulated in 1952 when Hall et al (31) first noted that aminotriazole had defoliating and regrowth inhibiting properties on cotton during the course of tests conducted at the Texas Agricultural Experimental Station.

In 1953, Shaw and Swanson (7) reported their study of the relationship between phytotoxicity and chemical structure of herbicides. Aminotriazole was again found to have the desirable properties of a promising herbicide.

The following year, W.W. Allen (32) of the American Chemical Paint Co. was granted a patent on the use of aminotriazole as a herbicide and cotton defoliant. After a number of field tests, aminotriazole was marketed by the American Chemical Paint Co. as a herbicide under the trade names - "Amizol" and "Weedazol". The American Cyanamid Co. was also licensed to manufacture and sell aminotriazole.

This compound whose derivatives had been used only sparingly as fog inhibitors in photographic emulsions (33) was reported to be more effective against Canada thistle than any other known herbicide. Prior to the use of aminotriazole, Canada thistle could only be kept under control by dosing with large amounts of soil sterilants or repeated applications of 2,4-D. Other weeds that were

also susceptible to control by aminotriazole included the following: quackgrass, nutgrass, Bermuda grass, poison ivy, poison oak, scrub oak, sow thistle, milkweed, horsetail rush, cattails, ash and red maple.

The fundamental reasons for the inherent herbicidal properties of aminotriazole are still obscure. It has been observed to cause chlorosis in plants. Sometimes the plant dies after the chlorosis. Generally, only new growth, in which pigment is being formed, becomes chlorotic. This has caused some (5) to suggest that chlorophyll synthesis is being affected. It has also been found that the degree of chlorosis is proportional to the amount of aminotriazole applied.

Kenneth A. Sund of the American Cyanamid Co. (34) has suggested that aminotriazole may affect plant physiological processes in three different ways: (1) as a precursor in the formation of some porphyrin similar to chlorophyll but unable to carry out the functions of chlorophyll; (2) it may bind by complex formation some metal or metals required for the development of chlorophyll; (3) it may upset some oxidation-reduction reactions within the plant.

By using radioactive 3-amino-1,2,4-triazole with the fifth position labeled with carbon-14, Miller and Hall (5) made a study to determine how aminotriazole effects chlorosis in plants. They suggested that aminotriazole in sub-lethal doses causes chlorosis by inhibiting the synthesis of chlorophylls and carotenoids. But when it is

applied in high concentrations, chlorosis is caused by the destruction of chlorophyll. From their studies they concluded that the possibility that aminotriazole acts as a precursor in the formation of an abnormal porphyrin is quite remote and that the complexing of an essential metal is unlikely. They agreed with Rogers (35) that aminotriazole inhibits plastid development.

While studying the depressing effect of aminotriazole on chlorophyll synthesis in plants, Heim et al (36) observed that the chemical also causes a great decrease in the catalase activity of plant tissue. This led them to study the effect of aminotriazole on catalase activity in rats. They found that aminotriazole reduced hepatic and renal catalase activity levels, but not that of red cells, thus producing an effect similar to that observed in tumor-bearing animals.

Tschudy and Collins (6) concluded that the ability of aminotriazole to affect two different porphyrin-containing compounds - catalase and chlorophyll - suggested a possible interference with porphyrin synthesis. They then studied the effect of aminotriazole on an enzyme known to be involved in porphyrin synthesis. They studied the effect of aminotriazole on δ-aminolevulinic acid dehydrase activity. This enzyme catalyzes the conversion of δ-aminolevulinic acid to porphobilinogen - an intermediate in the synthesis of porphyrins. They found

that aminotriazole reduces the level of δ-aminolevulinic acid dehydrase activity in the kidneys. It is significant that this effect is also produced by tumors. Thus tumors and aminotriazole are capable of causing a decrease in activity of both δ-aminolevulinic acid dehydrase and catalase.

Experimental

Phenylaminoguanidinium Bisulfate

A slurry of 304 g. (2.0 moles) of phenylthiourea (Eastman Kodak Co.) in 600 ml. of absolute methanol was cooled to 5° C. and then treated with 132 ml., 301 g. (2.12 moles) of methyl iodide. The mixture was allowed to remain in an ice bath as it warmed up to room temperature and stand for forty-eight hours. At the end of this period, 100 ml. of methanol were removed by distillation and then replaced by 100 ml. of fresh methanol. The flask was then placed in an ice bath and 67.4 g. (2 moles) of 95% hydrazine was added. The ice bath was then removed and the solution refluxed gently for four hours in the hood. The methyl mercaptan which is a by-product of this reaction was collected in a trap which was cooled in an ice-salt bath. The alcohol was then removed under reduced pressure until a viscous liquid remained. A volume of water equal to the volume of the viscous liquid was then added. This solution was again evaporated to a viscous liquid under reduced pressure. The viscous liquid was used in preparing the phenylaminoguanidinium bisulfate.

The viscous solution of the phenylaminoguanidinium iodide was dissolved in a solution of 60 ml. of concentrated sulfuric acid in 300 ml. of water. This solution was then added to a slurry of 327 g. (2.05 moles) of

silver sulfate in 200 ml. of water. The mixture became quite warm and yellow silver iodide precipitated. The mixture was stirred occasionally and permitted to stand overnight. The yellow silver iodide was collected on a filter and the filtrate was treated with hydrogen sulfide for about one hour until the precipitation of silver sulfide was complete. The solution was heated to coagulate the colloidal silver sulfide and then filtered. Next, it was treated with "Norit". After filtering, the colorless solution was evaporated to a viscous liquid under reduced pressure. The viscous liquid solidified on standing. It was dried in a vacuum desiccator and crushed while still soft to colorless granules. The yield of product was 400 g. (80% of theory based on the phenylthiourea). A sample for analysis was recrystallized from isopropyl alcohol and dried under a vacuum at 80° C. It melted at 94-96° C. (heated slowly) and near 85° C. when heated rapidly.

Anal. Calc'd. for $C_7H_{12}N_4O_4S$: N, 22.57; S,12.92
Found: N, 22.31; S, 12.81

3-Amino-4-phenyl-4-H,1,2,4-triazole

A mixture of 25 g. (0.1 mole) of phenylaminoguanidinium bisulfate and 50 ml. of 88% formic acid was refluxed for six hours. The excess formic acid was removed under reduced pressure and 40 ml. of water was

added. The solution was evaporated under reduced pressure to a viscous liquid, and 35 ml. of water was added. The solution was then carefully neutralized with solid sodium carbonate. Colorless crystals precipitated; they were separated by filtration and recrystallized from methanol. The yield of triazole was 12 g. (75% of theory). A sample for analysis was recrystallized twice from methanol and melted at 218-219° C.

Anal. Calc'd. for $C_8H_8N_4$: C, 60.00; H, 5.00; N, 35.00

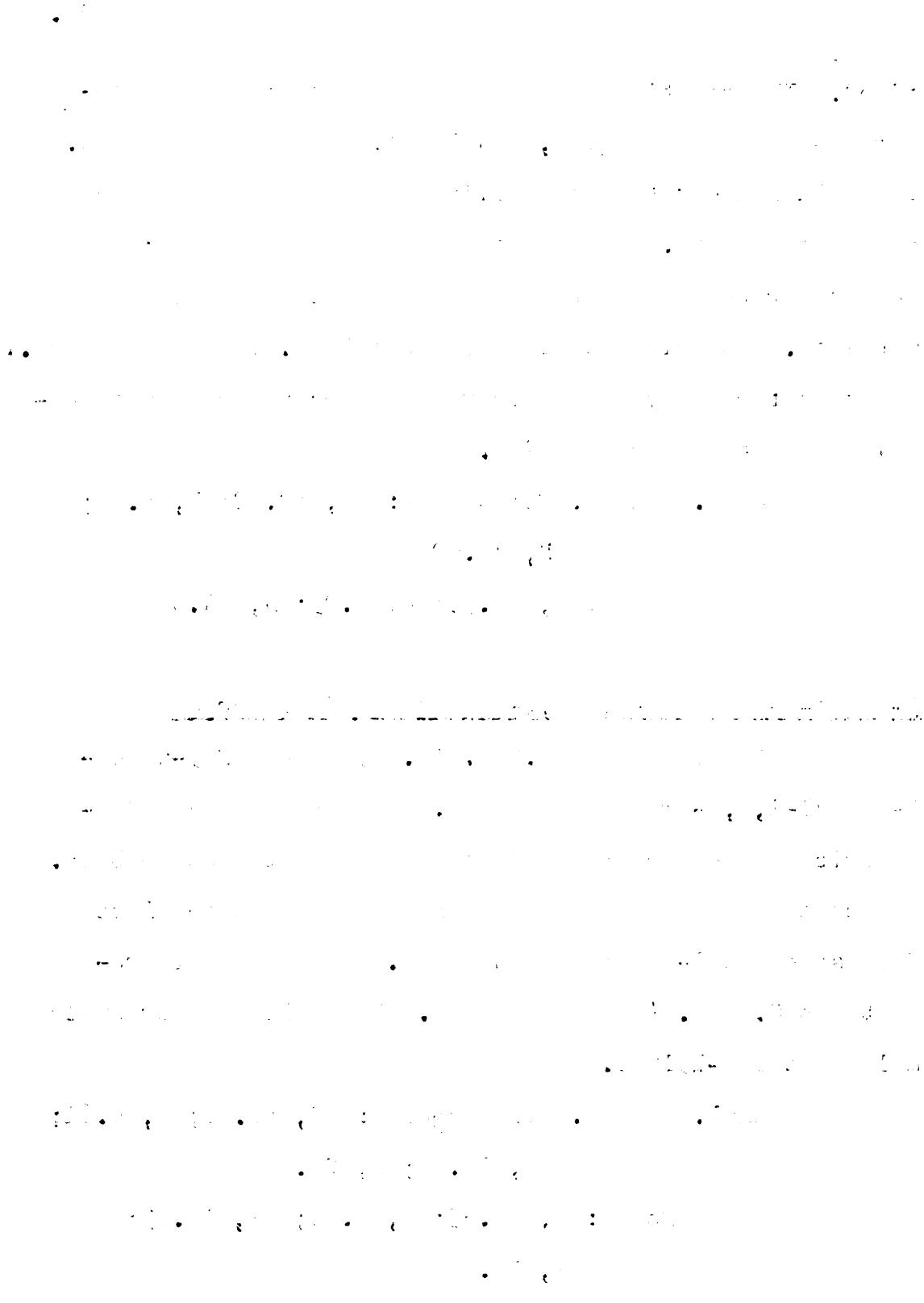
Found: C, 59.99; H, 5.03; N, 34.98

3-Amino-4-phenyl-4-H,1,2,4-triazole Hydrochloride

A solution of 0.8 g. (0.005 mole) of 3-amino-4-phenyl-1,2,4-triazole in 5 ml. of concentrated hydrochloric acid was evaporated to dryness on the steam bath. The crystalline residue was recrystallized three times from an ethanol-ether solvent pair. The yield of product was 0.88 g. (90% of theory). The colorless crystals melted at 190-191° C.

Anal. Calc'd. for $C_8H_9ClN_4$: C, 48.86; H, 4.61; Cl, 18.03; N, 28.49

Found: C, 48.55; H, 4.85; Cl, 18.03; N, 28.74



3-Acetamido-4-phenyl-4-H,1,2,4-triazole

Two grams (0.012 mole) of 3-amino-4-phenyl-1,2,4-triazole was treated with 20 ml. of acetic anhydride and refluxed for three hours. The excess acetic anhydride was removed under reduced pressure and 40 ml. of water was added to precipitate the product. The crystalline product was removed by filtration and washed with water. Recrystallization of the product three times from ethanol gave 1.5 g. (60% of theory) of colorless crystals melting at 201-202° C.

Anal. Calc'd. for $C_{10}H_{10}N_4O$: C, 59.40; H, 4.98
N, 27.72

Found: C, 59.58; H, 5.15; N, 27.72

The hydrolysis of 3-acetamido-4-phenyl-1,2,4-triazole by heating with concentrated hydrochloric acid produced a product which was identical with 3-amino-4-phenyl-1,2,4-triazole as shown by a mixture melting point determination. This suggests the absence of rearrangement of the original triazole in the process of acetylation. The original triazole also did not rearranged when heated above its melting point.

3-Amino-4-phenyl-5-methyl-4-H,1,2,4-triazole

A mixture of 25 g. (0.1 mole) of phenylaminoguanidinium bisulfate and 50 ml. of glacial acetic acid was refluxed for twelve hours. The excess acetic acid was removed under reduced pressure and 40 ml. of water was

added. The solution was evaporated under reduced pressure to a viscous liquid, and 35 ml. of water was added. The solution was then neutralized with solid sodium carbonate. Colorless crystals precipitated; they were removed by filtration and extracted with hot methanol. This solution was filtered while hot and cooled in an ice bath. Precipitation of the crystalline product took place. The yield of crude triazole was 13 g. (75% of theory). A sample for analysis was recrystallized twice from methanol and melted at 161-162° C.

Anal. Calc'd. for $C_9H_{10}N_4$: C, 62.10; H, 5.75; N, 32.20

Found: C, 62.05; H, 5.79; N, 32.17

3-Amino-4-phenyl-5-methyl-4-H,1,2,4-triazole Hydrochloride

A solution of 0.87 g. (0.005 mole) of 3-amino-4-phenyl-5-methyl-1,2,4-triazole in 5 ml. of concentrated hydrochloric acid was evaporated to dryness on the steam bath. The crystalline residue was recrystallized three times from an ethanol-ether solvent pair. The yield was 0.97 g. (92% of theory) of colorless crystals melting at 223-225° C.

Anal. Calc'd. for $C_9H_{11}ClN_4$: C, 51.31; H, 5.26 Cl, 16.83; N, 26.60

Found: C, 51.09; H, 5.44; Cl, 16.92; N,26.76

1-(4'-Phenyl-5'-methyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.003 mole) of 3-amino-4-phenyl-5-methyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for two hours and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration; washed with 50 ml. of ligroin, and recrystallized twice from methanol to yield 0.78 g. (90% of theory) of product melting at 186-188° C.

Anal. Calc'd. for $C_{16}H_{15}N_5S$: N, 22.64; S, 10.36

Found: N, 22.82; S, 10.28

3-Amino-4-phenyl-5-hydroxymethyl-4-H,1,2,4-triazole

A mixture of 25 g. (0.1 mole) of phenylaminoguanidinium bisulfate, 10 ml. of 70% glycolic acid, and 12 ml. of water was refluxed for twenty-two hours. The solution was then cooled and carefully neutralized with 7.5 M ammonia. Fine, cream-colored crystals precipitated. They were removed by filtration and washed with methanol. The yield of crude triazole was 14 g. (75% of theory). A sample for analysis was recrystallized three times from methanol and melted at 239-240° C.

Anal. Calc'd. for $C_9H_{10}N_4O$: C, 56.84; H, 5.26; N, 29.47

Found: C, 56.98; H, 5.18; N, 29.57

3-Amino-4-phenyl-5-hydroxymethyl-4-H,1,2,4-triazole Hydrochloride

A solution of 9.5 g. (0.05 mole) of 3-amino-4-phenyl-5-hydroxymethyl-1,2,4-triazole in 10 ml. of concentrated hydrochloric acid was evaporated to dryness on the steam bath. The crystalline residue was washed with acetone. A sample for analysis was recrystallized three times from an ethanol-ether solvent pair. The yield of hydrochloride was 10.6 g. (94% of theory). The colorless crystals melted at 218-220° C.

Anal. Calc'd. for $C_9H_{11}ClN_4O$: C, 47.69; H, 4.89
Cl, 15.64; N, 24.72
Found: C, 47.66; H, 4.97; Cl, 15.65;
N, 24.77

3-Amino-4-phenyl-5-(α-hydroxyethyl)-4-H,1,2,4-triazole

A mixture of 25 g. (0.1 mole) of phenylaminoguanidinium bisulfate, 12 ml. of 85% lactic acid and 24 ml. of water was refluxed for sixteen hours. The solution was then carefully neutralized with solid sodium carbonate. Colorless crystals precipitated, were removed by filtration and recrystallized from methanol. The yield of triazole was 7 g. (35% of theory). A small sample was further recrystallized once from ethanol and twice from isopropyl alcohol and melted at 205-207° C.

Anal. Calc'd. for $C_{10}H_{12}N_4O$: C, 58.81; H, 5.92;
N, 27.44
Found: C, 58.88; H, 6.09; N, 27.26

3-Acetamido-4-phenyl-5-(α-acetoxyethyl)-4-H,1,2,4-triazole

Two grams (0.01 mole) of 3-amino-4-phenyl-5-(α-hydroxyethyl)-1,2,4-triazole was treated with 20 ml. of acetic anhydride and refluxed for three hours. The excess acetic anhydride was removed under reduced pressure and 40 ml. of water was added to precipitate the product. The crystalline product was removed by filtration and washed with water. Recrystallization of the product three times from ethanol gave 1 g. (35% of theory) of colorless crystals melting at 201-203° C.

Anal. Calc'd. for $C_{14}H_{16}N_4O_3$: C, 58.32; H, 5.60; N, 19.43

Found: C, 58.26; H, 5.73; N, 19.22

3-Amino-4-phenyl-5-phenoxymethyl-4-H,1,2,4-triazole

A mixture of 7.6 g. (0.05 mole) of phenoxyacetic acid, 12.4 g. (0.05 mole) of phenylaminoguanidinium bisulfate, and 25 ml. of water was refluxed for twenty-two hours. The solution was then carefully neutralized with solid sodium carbonate; a gummy product precipitated. The aqueous layer was decanted and the product was recrystallized four times from toluene to yield 2.5 g. (20% of theory) of colorless crystals melting at 195-196° C.

Anal. Calc'd. for $C_{15}H_{14}N_4O$: C, 67.65; H, 5.30; N, 21.04

Found: C, 67.81; H, 5.44; N, 21.06

3-Amino-4-phenyl-5-phenoxymethyl-4-H,1,2,4-triazole Hydrochloride

A solution of 1.3 g. (0.005 mole) of 3-amino-4-phenyl-5-phenoxymethyl-1,2,4-triazole in 5 ml. of concentrated hydrochloric acid was evaporated to dryness on the steam bath. The crystalline residue was recrystallized three times from an ethanol-ether solvent pair. The yield of product was 1 g. (70% of theory), m.p. 198-199° C.

Anal. Calc'd. for $C_{15}H_{15}ClN_4O$: Cl, 11.71;
N, 18.51
Found: Cl, 11.84; N, 18.35

1-(4'-phenyl-5'-phenoxymethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 1 g. (0.004 mole) of 3-amino-4-phenyl-5-phenoxymethyl-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.6 g. (37% of theory) of product melting at 165-167° C.

Anal. Calc'd. for $C_{22}H_{19}N_5OS$: N, 17.44; S, 7.98
Found: N, 17.63; S, 7.94

3-Amino-4-phenyl-5-chloromethyl-4-H,1,2,4-triazole Hydrochloride

A slurry of 10.8 g. (0.048 mole) of the hydrochloride of 3-amino-4-phenyl-5-hydroxymethyl-1,2,4-triazole

in 25ml. of chloroform was treated with 10 g. (6 ml., 0.08 mole) of thionyl chloride in 15 ml. of chloroform. After thirty minutes at room temperature, the mixture was refluxed for six hours. Another addition of 6 g. (4 ml., 0.053 mole) of thionyl chloride in 10 ml. of chloroform was made and refluxing continued for four hours. The mixture became dark red and was permitted to stand overnight. The mixture was then cooled and stirred; a cream-colored solid precipitated. An additional crop of crystals was obtained by the addition of a small amount of ether to the filtrate. The product was washed with ether. The yield of chloromethyl triazole hydrochloride was 10.4 g. (86% of theory). A sample for analysis was recrystallized twice from a methanol-acetone solvent pair and melted at 188-190° C.

Anal. Calc'd. for $C_9H_{10}Cl_2N_4$: C, 44.10; H, 4.11; Cl, 28.93; N, 22.86

Found: C, 44.26; H, 4.23; Cl, 28.98; N, 22.59

3-Amino-4-phenyl-5-piperidinomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was treated with 12.75 g. (14.8 ml., 0.15 mole) of piperidine and allowed to stand for twenty-four hours. The piperidine hydrochloride was precipitated by the addition of ether. It was removed by filtration

and the filtrate was evaporated under reduced pressure until only a viscous liquid remained. The residue was treated with 25 ml. of concentrated hydrochloric acid, and the solution was again evaporated under reduced pressure until only a viscous liquid remained. Upon cooling, this liquid solidified to a colorless mass. The amine hydrochloride was washed with acetone and treated with a large excess of concentrated ammonia. Lustrous crystals appeared which were washed with concentrated ammonia and then with water. The yield of product was 11 g. (84% of theory). The amine was recrystallized twice from toluene and melted at 153-154° C.

Anal. Calc'd. for $C_{14}H_{19}N_5$: C, 65.33; H, 7.44; N, 27.22

Found: C, 65.43; H, 7.47; N, 27.39

When the free amine was refluxed in acetic anhydride for five hours, no product could be isolated. When acetic acid was used in place of the anhydride, the free amine was recovered unchanged.

1-(4'-Phenyl-5'-piperidinomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-piperidinomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product began. The

phenylthiourea derivative was removed by filtration, washed with ligroin, and recrystallized twice from methanol to yield 0.6 g. (77% of theory) of product melting at 184-186° C.

Anal. Calc'd. for $C_{21}H_{24}N_6S$: N, 21.41; S, 8.17

Found: N, 21.39; S, 8.03

3-Amino-4-phenyl-5-morpholinomethyl-4-H,1,2,4-triazole

A solution of 24.5 g. (0.1 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 100 ml. of methanol was treated with 26.13 g. (26 ml., 0.3 mole) of morpholine and allowed to stand for twenty-four hours. The morpholine hydrochloride was precipitated by the addition of ether and removed by filtration. The filtrate was evaporated under reduced pressure until only a viscous liquid remained. The residue was treated with 25 ml. of concentrated hydrochloric acid, and the solution was again evaporated under reduced pressure until only a viscous liquid remained. Upon cooling, this liquid solidified to a colorless mass. The amine hydrochloride was washed with acetone and treated with a large excess of concentrated ammonia. Lustrous crystals appeared which were washed with concentrated ammonia and then with water. The yield of base was 13 g. (50% of theory). The product was recrystallized twice from methanol and melted at 204-205° C.

Anal. Calc'd. for $C_{13}H_{17}N_5O$: C, 60.20; H, 6.61; N, 27.01

Found: C, 59.91; H, 6.69; N, 26.89

1-(4'-Phenyl-5'-morpholinomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-morpholinomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin, and recrystallized twice from methanol to yield 0.6 g. (77% of theory) of product melting at 176-178° C.

Anal. Calc'd. for $C_{20}H_{22}N_6OS$: N, 21.31; S, 8.13

Found: N, 21.40; S, 8.15

3-Amino-4-phenyl-5-pyrrolidinomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was treated with 10.65 g. (12.2 ml., 0.15 mole) of pyrrolidine and allowed to stand for forty-eight hours. The pyrrolidine hydrochloride was precipitated as a dark heavy oil by the addition of 200 ml. of anhydrous ether. The clear upper layer of the mixture was decanted and evaporated under reduced pressure until

only a viscous liquid remained. The residue was treated with 25 ml. of concentrated hydrochloric acid, and the solution was again evaporated under reduced pressure until only a viscous liquid remained. Upon cooling, the amine hydrochloride precipitated as a hygroscopic, colorless solid. After triturating with acetone, it was treated with a large excess of concentrated ammonia. Lustrous crystals appeared which were washed with concentrated ammonia and then with water. The yield of base was 6 g. (50% of theory). It was recrystallized three times from toluene and melted at 158-160° C. A sample was further recrystallized once from toluene, three times from acetone and treated with "Norit"; it also melted at 158-160° C.

Anal. Calc'd. for $C_{13}H_{17}N_5$: C, 64.17; H, 7.05; N, 28.79

Found: C, 64.34; H, 7.17; N, 28.75

<u>1-(4'-Phenyl-5'-pyrrolidinomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea</u>

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-pyrrolidinomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin, and recrystallized twice from

methanol to yield 0.4 g. (53% of theory) of product melting at 178-180° C.

Anal. Calc'd. for $C_{20}H_{22}N_6S$: N, 22.21; S, 8.47

Found: N, 22.43; S, 8.40

3-Amino-4-phenyl-5-dimethylaminomethyl-4-H,1,2,4-triazole

A solution of dimethylamine was prepared by treating 24.5 g. (0.3 mole) of dimethylamine hydrochloride with a solution of 12 g. (0.3 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. After cooling the mixture, the sodium chloride which had precipitated was removed by filtration. This solution of dimethylamine was then treated with a solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol contained in an Erlenmeyer flask. After the initial reaction had subsided, the flask was stoppered and permitted to stand for ninety-six hours. It was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate was evaporated to dryness under reduced pressure. A yellow solid remained in the flask. The solid was extracted with hot toluene. A colorless product precipitated from the toluene extract upon cooling. The product was recrystallized from toluene five times to yield 4 g. (36% of theory) of colorless

crystals melting at 139-140° C.

Anal. Calc'd. for $C_{11}H_{15}N_5$: C, 60.80; H, 6.96; N, 32.23

Found: C, 60.60; H, 7.07; N, 32.04

1-(4'-Phenyl-5'-dimethylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-dimethylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with 50 ml. of ligroin, and recrystallized twice from methanol to yield 0.7 g. (87% of theory) of product melting at 182-183° C.

Anal. Calc'd. for $C_{18}H_{20}N_6S$: N, 23.85; S, 9.10

Found: N, 23.65; S, 8.96

3-Amino-4-phenyl-5-diethylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of absolute ethanol was placed in an Erlenmeyer flask and cooled. It was then treated with 62 ml. (0.6 mole) of diethylamine. Twenty-five milliliters of methanol was added; cooling was discontinued and the flask was stoppered and permitted to stand for sixty-eight hours. A solution of 4 g. (0.1 mole) of sodium hydroxide in

25 ml. of water was diluted with 50 ml. of methanol and then added to the reaction mixture. The sodium chloride which precipitated was removed by filtration and the excess solvent and liberated diethylamine were removed under reduced pressure. A pinkish-white solid remained in the flask. The solid was extracted with hot toluene. A colorless product precipitated from the toluene extract upon cooling. It was recrystallized three times from toluene and melted at 148-150° C. The yield of product was 8 g. (75% of theory).

Anal. Calc'd. for $C_{13}H_{19}N_5$: C, 63.65; H, 7.81; N, 28.55

Found: C, 63.65; H, 8.00; N, 28.40

1-(4'-Phenyl-5'-diethylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-diethylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin, and recrystallized twice from methanol to yield 0.7 g. (90% of theory) of product melting at 171-172° C.

Anal. Calc'd. for $C_{20}H_{24}N_6S$: N, 22.09; S, 8.43

Found: N, 21.90; S, 8.22

3-Amino-4-phenyl-5-diallylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was placed in an Erlenmeyer flask and treated with 29 g. (38 ml., 0.3 mole) of diallylamine. After the initial reaction had subsided, the flask was stoppered and permitted to stand for seventy-two hours. The reaction mixture was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate evaporated to dryness under reduced pressure. A yellow solid remained in the flask. The solid was recrystallized five times from ligroin to yield 3.4 g. (25% of theory) of product as yellow crystals melting at 92-93° C.

Anal. Calc'd. for $C_{15}H_{19}N_5$: C, 66.88; H, 7.11; N, 26.00

Found: C, 66.56; H, 7.37; N, 26.16

1-(4'-Phenyl-5'-diallylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-diallylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration,

washed with ligroin and recrystallized twice from methanol to yield 0.5 g. (71% of theory) of product melting at 144-145° C.

Anal. Calc'd. for $C_{22}H_{24}N_6S$: N, 20.76; S, 7.93
Found: N, 20.76; S, 7.95

3-Amino-4-phenyl-5-di-n-propylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was placed in an Erlenmeyer flask and treated with 15 g. (20.4 ml., 0.15 mole) of di-n-propylamine. After the initial reaction had subsided, the flask was stoppered and permitted to stand for seventy-two hours. The reaction mixture was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate was evaporated to dryness under reduced pressure. The yellow solid that remained in the flask was recrystallized four times from toluene and twice from an ethanol-water solvent pair to yield 4 g. (26% of theory) of faintly yellow crystals melting at 142-143° C.

Anal. Calc'd. for $C_{15}H_{23}N_5$: C, 65.90; H, 8.48; N, 25.62
Found: C, 65.72; H, 8.60; N, 25.45

2-Amino-4-phenyl-5-di-n-propylaminomethyl-4-H-1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was placed in an Erlenmeyer flask and treated with 15 g. (20.4 ml., 0.15 mole) of di-n-propylamine. After the initial reaction had subsided, the

1-(4'-Phenyl-5'-di-n-propylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-di-n-propylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin, and recrystallized twice from methanol to yield 0.6 g. (82% of theory) of product melting at 157-158° C.

Anal. Calc'd. for $C_{22}H_{28}N_6S$: N, 20.58; S, 7.85

Found: N, 20.46; S, 7.68

3-Amino-4-phenyl-5-di-isopropylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol was placed in an Erlenmeyer flask and treated with 15 g. (21 ml., 0.15 mole) of di-isopropylamine. After the initial reaction had subsided, the flask was stoppered and permitted to stand for one week. The reaction mixture was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate evaporated to dryness under reduced pressure. The yellow solid which remained in the flask was recrystallized four times from

toluene and twice from methanol to yield 4 g. (26% of theory) of faintly yellow crystals melting at 192-193° C.

Anal. Calc'd. for $C_{15}H_{23}N_5$: C, 65.90; H, 8.48; N, 25.62

Found: C, 65.71; H, 8.45; N, 25.92

1-(4'-Phenyl-5'-di-isopropylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-di-isopropylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin and recrystallized twice from methanol to yield 0.66 g. (90% of theory) of product melting at 170-171° C.

Anal. Calc'd. for $C_{22}H_{28}N_6S$: N, 20.58; S, 7.85

Found: N, 20.64; S, 7.79

3-Amino-4-phenyl-5-di-n-butylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of absolute methanol was placed in an Erlenmeyer flask and treated with 19.35 g., 26 ml. (0.15 mole) of di-n-butylamine. After the initial reaction had subsided,

[illegible]

[illegible]

the flask was stoppered and permitted to stand for seventy-two hours. The reaction mixture was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate was evaporated to dryness under reduced pressure. The yellow solid which remained in the flask was extracted with hot toluene. A colorless product precipitated from the toluene extract upon cooling. The yield of product was 13.5 g. (90% of theory). A small sample was recrystallized three times from toluene and melted at 135-136° C.

Anal. Calc'd. for $C_{17}H_{27}N_5$: C, 67.74; H, 9.03; N, 23.24

Found: C, 67.48; H, 9.22; N, 23.07

1-(4'-Phenyl-5'-di-n-butylaminomethyl-4'-H,1',2',4' triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-di-n-butylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin and recrystallized twice from methanol to yield 0.63 g. (90% of theory) of product melting at 129-130° C.

Anal. Calc'd. for $C_{24}H_{32}N_6S$: N, 19.25; S, 7.34

Found: N, 19.12; S, 7.36

3-Amino-4-phenyl-5-di-isobutylaminomethyl-4-H,1,2,4-triazole

A solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of absolute methanol was placed in an Erlenmeyer flask and treated with 19.35 g., 26 ml. (0.15 mole) of di-isobutylamine. After the initial reaction had subsided, the flask was stoppered and permitted to stand for five days. The reaction mixture was then treated with a solution of 4 g. (0.1 mole) of sodium hydroxide in 10 ml. of water and 50 ml. of methanol. The sodium chloride which precipitated was removed by filtration and the filtrate evaporated to dryness under reduced pressure. The yellow solid which remained in the flask was extracted with hot toluene. A colorless product precipitated from the toluene extract upon cooling. The yield of product was 10 g. (66% of theory). A small sample was recrystallized three times from toluene and melted at 189-191° C.

Anal. Calc'd. for $C_{17}H_{27}N_5$: C, 67.74; H, 9.03; N, 23.24

Found: C, 67.88; H, 9.03; N, 23.19

1-(4'-Phenyl-5'-di-isobutylaminomethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-di-isobutylaminomethyl-1,2,4-triazole and 2 ml. of phenylisothiocyanate was heated on the steam bath for one hour and then cooled in an ice bath. The flask was

scratched until precipitation of the product occurred. The phenylthiourea derivative was removed by filtration, washed with ligroin and recrystallized twice from methanol to yield 0.6 g. (85% of theory) of product melting at 168-169° C.

Anal. Calc'd. for $C_{24}H_{32}N_6S$: N, 19.25; S, 7.34
Found: N, 19.13; S, 7.50

3-Amino-4-phenyl-5-phenoxymethyl-4-H,1,2,4-triazole

A solution of 4.7 g. (0.05 mole) of phenol in 25 ml. of methanol was treated with a solution of 4.5 g. (0.11 mole) of sodium hydroxide in 10 ml. of water. This solution of sodium phenoxide was then added to a solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for twenty-four hours. The precipitated product was removed by filtration, and additional crystals were obtained by adding water to the filtrate. Both crops of crystals were combined and washed three times with 200 ml. of water. The product was recrystallized four times from toluene to yield 8 g. (60% of theory) of colorless crystals melting at 195-196° C. The product obtained in this reaction was identical with that obtained from the reaction of phenoxyacetic acid with phenylaminoguanidinium bisulfate as shown by a mixture melting point determination.

3-Amino-4-phenyl-5-(p-bromophenoxymethyl)-4-H,1,2,4-triazole

A solution of 8.6 g. (0.05 mole) of p-bromophenol in 10 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium p-bromophenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for forty hours. Precipitation of the product began within five minutes. The product was removed by filtration and additional product was obtained by adding water to the filtrate. Both crops of crystals were combined and washed three times with 200 ml. of water. The product was then recrystallized three times from methanol to yield 3 g. (35% of theory) of colorless crystals melting at 182-183° C.

Anal. Calc'd. for $C_{15}H_{13}BrN_4O$: C, 52.19; H, 3.79; Br, 23.15; N, 16.23

Found: C, 52.26; H, 3.82; Br, 23.24; N, 16.28

1-[4'-Phenyl-5'-(p-bromophenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.003 mole) of 3-amino-4-phenyl-5-(p-bromophenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated

with 50 ml. of ligroin to precipitate the phehylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 1 g. (69% of theory) of product melting at 188-190° C.

Anal. Calc'd. for $C_{22}H_{18}BrN_5OS$: Br, 16.63; N, 14.58; S, 6.67

Found: Br, 16.47; N, 14.80; S, 6.67

3-Amino-4-phenyl-5-(p-chlorophenoxymethyl)-4-H,1,2,4-triazole

A solution of 6.5 g. (0.05 mole) of p-chlorophenol in 25 ml. of methanol was treated with a solution of 5 g. (0.125 mole) of sodium hydroxide in 10 ml. of water. This solution of sodium p-chlorophenoxide was then added to a solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for one week. The precipitated product was removed by filtration. Additional crystals were obtained by adding water to the filtrate. Both crops of crystals were combined and washed three times with 200 ml. of water. The product was recrystallized three times from methanol to yield 8 g. (55% of theory) of colorless crystals melting at 197-198° C.

Anal. Calc'd. for $C_{15}H_{13}ClN_4O$: C, 59.90; H, 4.35; Cl, 11.79; N, 18.63

Found: C, 59.81; H, 4.43; Cl, 12.08; N, 18.86

1-[4'-Phenyl-5'-(p-chlorophenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.003 mole) of 3-amino-4-phenyl-5-(p-chlorophenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.6 g. (44% of theory) of product melting at 185-186° C.

Anal. Calc'd. for $C_{22}H_{18}ClN_5OS$: Cl, 8.13; N, 16.07; S, 7.36

Found: Cl, 8.03; N, 16.22; S, 7.28

3-Amino-4-phenyl-5-(p-methoxyphenoxymethyl)-4-H,1,2,4-triazole

A solution of 7 g. (0.056 mole) of p-methoxyphenol in 25 ml. of methanol was treated with a solution of 5 g. (0.125 mole) of sodium hydroxide in 10 ml. of water. This solution of sodium p-methoxyphenoxide was then added to a solution of 12.25 g. (0.05 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 50 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for twenty-four hours. The solution became intensely red and after five hours beautiful, colorless needles precipitated. The precipitated

product was removed by filtration and additional crystals were obtained by adding water to the filtrate. Both crops of crystals were combined and washed three times with 200 ml. of water. The product was recrystallized three times from methanol to yield 9 g. (60% of theory) of colorless needles melting at 179-180° C.

Anal. Calc'd. for $C_{16}H_{16}N_4O_2$: C, 64.85; H, 5.44; N, 18.91

Found: C, 64.82; H, 5.42; N, 18.85

1-[4'-Phenyl-5'-(p-methoxyphenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.003 mole) of 3-amino-4-phenyl-5-(p-methoxyphenoxymethyl)-4-H,1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.7 g. (50% of theory) of product melting at 177-178° C.

Anal. Calc'd. for $C_{23}H_{21}N_5O_2S$: N, 16.23; S, 7.43

Found: N, 16.43; S, 7.11

3-Amino-4-phenyl-5-(p-methylphenoxymethyl)-4-H,1,2,4-triazole

A solution of 5.4 g. (5.4 ml., 0.05 mole) of p-cresol in 10 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium p-methylphenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for twenty-four hours. Precipitation of the product began within five minutes. The precipitated product was removed by filtration and additional crystals were obtained by adding water to the filtrate. Both crops of crystals were combined and washed three times with 200 ml. of water. The product was recrystallized four times from methanol to yield 5 g. (71% of theory) of colorless crystals melting at 168-169° C.

Anal. Calc'd. for $C_{16}H_{16}N_4O$: C, 68.55; H, 5.75; N, 19.99

Found: C, 68.41; H, 5.92; N, 19.99

1-[4'-Phenyl-5'-(p-methylphenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.0035 mole) of 3-amino-4-phenyl-5-(p-methylphenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for

two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.7 g. (50% of theory) of product melting at 168-169° C.

Anal. Calc'd. for $C_{23}H_{21}N_5OS$: N, 16.85; S, 7.71

Found: N, 17.07; S, 7.56

3-Amino-4-phenyl-5-(o-methylphenoxymethyl)-4-H,1,2,4-triazole

A solution of 5.4 g. (5.4 ml., 0.05 mole) of o-cresol in 10 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium o-methylphenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for twenty-four hours. Precipitation of the product began within thirty minutes. Finally the mixture was heated for thirty minutes on the steam bath, cooled and treated with water. The colorless, crystalline product was removed by filtration and recrystallized three times from ethanol to yield 2 g. (30% of theory) of colorless crystals melting at 186-187° C.

Anal. Calc'd. for $C_{16}H_{16}N_4O$: C, 68.55; H, 5.75; N, 19.99

Found: C, 68.61; H, 5.76; N, 19.87

1-[4'-Phenyl-5'-(o-methylphenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.0035 mole) of 3-amino-4-phenyl-5-(o-methylphenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.6 g. (43% of theory) of product melting at 182-183° C.

Anal. Calc'd. for $C_{23}H_{21}N_5OS$: N, 16.85; S, 7.71

Found: N, 17.00; S, 7.41

3-Amino-4-phenyl-5-(m-methylphenoxymethyl)-4-H,1,2,4-triazole

A solution of 5.4 g. (5.4 ml., 0.05 mole) of m-cresol in 10 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium m-methylphenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for forty-eight hours. The solution was then heated on the steam bath for thirty minutes, cooled and treated with water. An oil separated which crystallized upon cooling in an ice bath. The product

was recrystallized three times from toluene to yield 2 g. (30% of theory) of colorless needles melting at 155-157° C.

Anal. Calc'd. for $C_{16}H_{16}N_4O$: C, 68.55; H, 5.75; N, 19.99

Found: C, 68.55; H, 5.90; N, 20.23

1-[4'-Phenyl-5'-(m-methylphenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 1 g. (0.0035 mole) of 3-amino-4-phenyl-5-(m-methylphenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.5 g. (35% of theory) of product melting at 166-167° C.

Anal. Calc'd. for $C_{23}H_{21}N_5OS$: N, 16.85; S, 7.71

Found: N, 17.15; S, 7.53

3-Amino-4-phenyl-5-thiophenoxymethyl-4-H,1,2,4-triazole

A solution of 5 g. (5 ml., 0.05 mole) of thiophenol in 10 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium thiophenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of

methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for seventy-two hours. The mixture was then heated on the steam bath for one hour, cooled and treated with 200 ml. of water. The product which precipitated was removed by filtration and washed with water. It was recrystallized three times from toluene to yield 4 g. (57% of theory) of colorless crystals melting at 130-132° C.

Anal. Calc'd. for $C_{15}H_{14}N_4S$: C, 63.80; H, 4.97; N, 19.84; S, 11.35

Found: C, 63.72; H, 5.14; N, 19.86; S, 11.47

1-(4'-Phenyl-5'-thiophenoxymethyl-4'-H,1',2',4'-triazolyl-3')-3-phenylthiourea

A mixture of 1 g. (0.0035 mole) of 3-amino-4-phenyl-5-thiophenoxymethyl-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.5 g. (43% of theory) of product melting at 141-143° C.

Anal. Calc'd. for $C_{22}H_{19}N_5S_2$: N, 16.77; S, 15.36

Found: N, 16.70; S, 15.50

3-Amino-4-phenyl-5-(p-chlorothiophenoxymethyl)-4-H,1,2,4-triazole

A solution of 7.2 g. (0.05 mole) of p-chlorothiophenol in 25 ml. of methanol was treated with a solution of 3 g. (0.075 mole) of sodium hydroxide in 6 ml. of water. This solution of sodium p-chlorothiophenoxide was then added to a solution of 6 g. (0.025 mole) of the hydrochloride of 3-amino -4-phenyl-5-chloromethyl-1,2,4-triazole in 25 ml. of methanol. After the initial reaction had subsided, the flask was stoppered and permitted to stand for sixty hours. The solution was then heated on the steam bath for thirty minutes, cooled and treated with 200 ml. of water. An oil separated which crystallized upon cooling in an ice bath. The product was recrystallized three times from toluene to yield 4 g. (50% of theory) of colorless crystals melting at 121-122° C.

Anal. Calc'd. for $C_{15}H_{13}ClN_4S$: C, 56.86; H, 4.13;
Cl, 11.19; N, 17.69; S, 10.12;
Found: C, 57.13; H, 4.25; Cl, 11.22;
N, 17.90; S, 9.92

1-[4'-Phenyl-5'-(p-chlorothiophenoxymethyl)-4'-H,1',2',4'-triazolyl-3']-3-phenylthiourea

A mixture of 0.5 g. (0.002 mole) of 3-amino-4-phenyl-5-(p-chlorothiophenoxymethyl)-1,2,4-triazole and 3 ml. of phenylisothiocyanate was heated on the steam bath

for two hours. It was then cooled in an ice bath and treated with 50 ml. of ligroin to precipitate the phenylthiourea derivative. The product was removed by filtration and recrystallized twice from methanol to yield 0.4 g. (57% of theory) of product melting at 167-168° C.

Anal. Calc'd. for $C_{22}H_{18}ClN_5S_2$: Cl, 7.84; N, 15.50; S, 14.19

Found: Cl, 7.96; N, 15.52; S, 14.06

Summary

In the course of this investigation, three different series of compounds having varied substituents in the fifth position of 3-amino-4-phenyl-4-H,1,2,4-triazole were synthesized. The starting material for these syntheses, phenylaminoguanidinium bisulfate, was first prepared in the course of this work.

A procedure was perfected for the conversion of 3-amino-4-phenyl-5-hydroxymethyl-1,2,4-triazole to the hydrochloride of 3-amino-4-phenyl-5-chloromethyl-1,2,4-triazole in good yield. The latter was a required intermediate for the synthesis of the 5-dialkylaminomethyl-, the 5-phenoxymethyl-, and the 5-thiophenoxymethyltriazoles.

Phenylthiourea derivatives of most of these new aminotriazoles were prepared. In a few cases, a number of the hydrochlorides and acetyl derivatives were prepared.

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