of the bottle and stopcock *A* is set into the bottle, allowing the bottle to be handled as any ordinary reagent bottle, as well as supplying a long-felt necessity, that of knowing the amount of reagent one is using either in qualitative or quantitative work, without going to the necessary trouble of using cylinders, pipettes, etc. One is also positive that no other reagent or dirt of any kind has come in contact with the measuring apparatus.

This bottle is manipulated in the same manner as the normal solution bottle, only held in the hand instead of a support. FRANK M. DAVIS.

MACANDREWS AND FORBES CO.,
CAMDEN, N. J.

[CONTRIBUTIONS FROM THE SHEFFIELD LABORATORY OF YALE UNIVERSITY.]

METATHETICAL REACTIONS: ETHER-THIOUREAS AND THEIR RELATION TO PSEUDOAMMONIUM BASES.

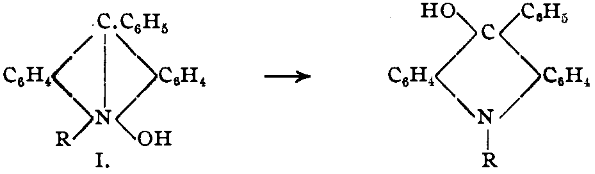
BY TREAT B. JOHNSON AND HERBERT H. GUEST.[1]

Received June 18, 1910.

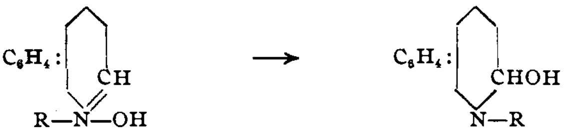
Contents.

I. Pseudoammonium Bases and Their Alcoholates.

A characteristic feature of cyclic, quaternary bases (ammonium bases) is their tendency to undergo isomerization in aqueous solution. The hydroxyl group of the base migrates from nitrogen to a carbon atom, giving trivalent-nitrogen compounds or pseudoammonium bases (*ψ-ammonium bases*).[2] Decker calls these rearrangement products *oxydihydro* or *carbinol* bases.[3] These transformations in the acridine (I), quinoline (II) and isoquinoline (III) series are represented by the following formulas:



I. IV.



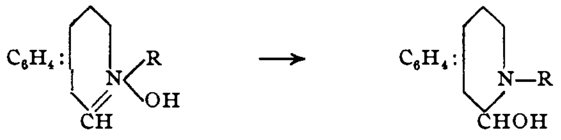
II. V.

---

[1] Presented at the San Francisco meeting of the American Chemical Society.

[2] Hantzsch and Kalb, *Ber.*, 32, 575, 3109.

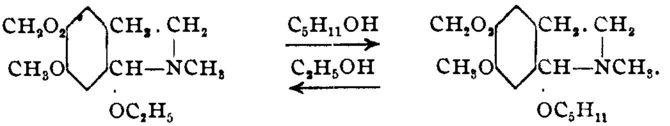
[3] *Ber.*, 25, 3327.



III. VI.

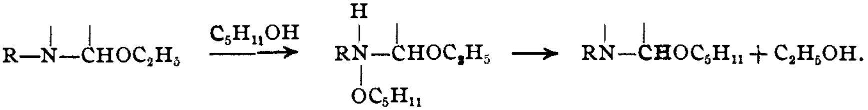
The pseudoammonium bases IV, V, VI (pyridines, quinolines, isoquinolines and acridines) are especially characterized by their behavior towards alcohols. They react at ordinary temperature, with loss of a molecule of water, giving alcoholates or ethers (Sauerstoffäther)[1] which are capable of undergoing unique transformations when warmed with alcohols. The characteristic behavior of these cyclic alcoholates is summarized in the following quotation from a paper by Decker[2] on the alcoholates of some quinoline pseudoammonium bases:

"Gegenüber Alkoholen mit anderen Radikalen verhalten sich die Alkoholate in der Weise, dass sie ihren an Sauerstoff gebundenen Alkylrest leicht und glatt gegen den Rest des in Überschuss angewandten anderen Alkohols umtauschen. So wurde das Methylalkoholat in einem Überschuss von Benzylalkohol unter Erwärmen gelöst und nach erkalten krystallisirte das characteristische Benzylalkoholate heraus." Kuntze,[3] for example, has recently shown that ethoxyhydrocotarnine (VII) and *l*-amoxyhydrocotarnine (VIII) react with *l*-amyl and ethyl alcohol, respectively, on warming, with transposition of their alkyl groups.



VII. VIII.

Two theories have been advanced to explain the mechanism of this reaction of an alcoholate with alcohols. According to Decker[4] the alcohol first adds to the nitrogen atom of the alcoholate giving an unstable addition product, which then loses a molecule of alcohol giving a new alcoholate. This change involves necessarily a rearrangement of an alkoxy group from nitrogen to the carbon atom. These changes are represented by the following formulas:



$$R{-}\overset{|}{N}{-}\overset{|}{C}HOC_2H_5 \xrightarrow{C_5H_{11}OH} R\overset{H}{\underset{OC_5H_{11}}{N}}{-}\overset{|}{C}HOC_2H_5 \longrightarrow R\overset{|}{N}{-}\overset{|}{C}HOC_5H_{11} + C_2H_5OH.$$

---

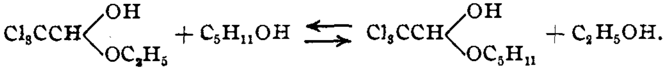
[1] Roser, *Ann.*, **254**, 362. Freund, *Ber.*, **22**, 2337. Decker, *Ann.*, **254**, 360. *Ber.*, **25**, 3327; **33**, 1715. Freund and Bamberger, *Ber.*, **25**, 1753.

[2] *J. prakt. Chem.*, **45**, 182. See also *Ber.*, **25**, 3327.

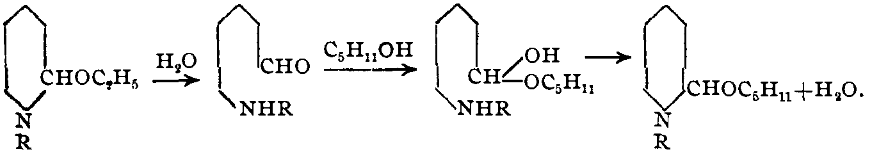
[3] *Arch. Pharm.*, **246**, 110 (1908).

[4] *Ber.*, **33**, 1715.

Gadamer[1] **takes issue with** Decker[2] and interprets these transformations of quinoline and isoquinoline alcoholates by typical, aldehyde reactions. According to him, the reaction is perfectly analogous to the action of alcohols on chloral alcoholates.[3] He assumes that the cyclic alcoholates undergo partial dissociation in solution into alcohol and an aldehyde base. The latter then reacts with the alcohol in excess, by mass action, giving an aldehyde alcoholate, which then condenses to a new alcoholate of the pseudobase. These changes are represented by the following formulas:



$$\mathrm{Cl_3CCH}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{OC_2H_5}\end{matrix}\right. + \mathrm{C_5H_{11}OH} \rightleftarrows \mathrm{Cl_3CCH}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{OC_5H_{11}}\end{matrix}\right. + \mathrm{C_2H_5OH}.$$



He writes:[4] "Jedenfalls ist die Auffassung Deckers bezuglich der Ueberführung eines Alkoholates in ein anderes nicht haltbar. Man massenwirkung annehmen müssen. Diese setzt aber veraus, dass die Alkoholate in Aldehydbase und Alkohol dissoziiert sind."

The mechanism of these characteristic, metathetical reactions is still a subject of polemic. Therefore, with the possibility of obtaining new data which might contribute to our present knowledge of these transformations, it seemed desirable to investigate the behavior, towards alcohols, of some acyclic nitrogen compounds related in structure to cyclic pseudoammonium alcoholates. We selected, therefore, for our study some representatives of a new class of thioureas—*ether-thioureas*—recently described in this laboratory.

II. Ether-thioureas and Their Behavior towards Alcohols.

In a previous paper from this laboratory, the writers[5] have shown that certain primary halogen-ethers (IX) react smoothly with potassium thiocyanate giving isothiocyanates (X). We described isothiocyanodimethyl-, isothiocyanomethylethyl- and isothiocyanomethylisoamyl ethers and also several representatives of a new class of thioureas—*ether-thioureas* (XI). The latter were obtained by the action of these isothiocyanates on organic bases.

$\mathrm{RO.CH_2Cl}$	$\mathrm{RO.CH_2NCS}$	$\mathrm{ROCH_2NHCSNHR'}$
IX.	X.	XI.

($\mathrm{R = CH_3, C_2H_5}$. $\mathrm{R' = C_6H_5}$, etc.)

---

[1] *Arch. Pharm.*, **243,** 12; **246,** 89. Gadamer and Kuntze, *Ibid.*, **246,** 91.

[2] *Loc. cit.*

[3] Kuntze, *Loc. cit.*

[4] *Arch. Pharm.*, **246,** 96.

[5] *Am. Chem. J.*, **41,** 337 (1909).

If a comparison is made of the structural formula of a pyridine alcoholate with that of an ether-thiourea, the fact is revealed that the thiourea and cyclic derivative are very closely related. In fact, the thiourea contains the same linking $=\underset{|}{C}.\underset{|}{N}.\underset{|}{C}H.OR$ as the cyclic alcoholate, and may be regarded as an acyclic pseudoammonium compound. These thioureas, therefore, might be expected to undergo transformations


(Cyclic) (Acyclic)

($R = CH_3, C_2H_5$. $R' = C_6H_5$, C_7H_7, etc.)

with alcohols analogous to those which have been observed to take place with the cyclic alcoholates. Our observations have confirmed such an assumption.

We find that it is a characteristic feature of every ether-thiourea which we have examined, to react with alcohols, on warming, with transposition of the alkyl groups. In order to purify them by crystallization from an alcohol it is necessary to use, as solvent, an alcohol containing the same alkyl group as that attached to oxygen in the ether-thiourea. Furthermore, the reactions are reversible and are not influenced by the

$$R.NHCSNHCH_2OC_2H_5 + CH_3OH \rightleftarrows R.NHCSNHCH_2OCH_3 + C_2H_5OH,$$

boiling points of the alcohols, or by the size of the alkyl groups involved in the change.

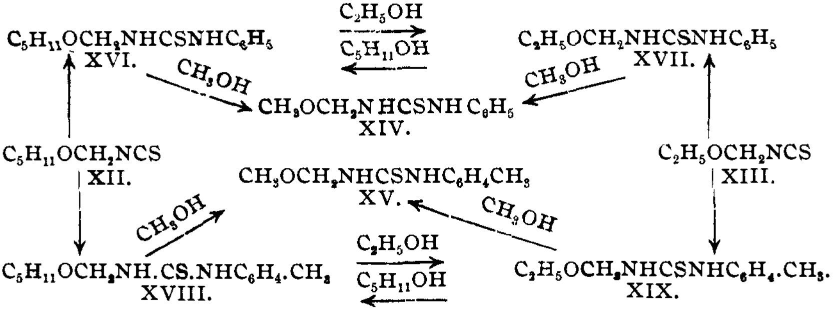
Our experiments were performed with the phenyl and *p*-tolyl ether-thioureas obtained by the action of aniline and *p*-toluidine on isothiocyanomethyl-, -methylethyl and -methylisoamyl ethers.[1] 1-Phenyl-2-isoamoxymethylthiourea (XVI) and 1-phenyl-2-ethoxymethylthiourea (XVII) were both converted smoothly into 1-phenyl-2-methoxymethylthiourea (XIV) by crystallization from methyl alcohol. The structure of this methoxy compound was established by the fact that it was identical with the methoxythiourea obtained by the action of aniline on isothiocyanodimethylether. Crystallization of 1-phenyl-2-isoamoxymethylthiourea (XVI) from ethyl alcohol gave 1-phenyl-2-ethoxymethylthiourea (XVII) which is changed practically quantitatively into the original isoamoxy compound by recrystallization from isoamyl alcohol.

Analogous transformations were obtained with the corresponding *p*-tolyl compounds: 1-Paratolyl-2-methoxymethylthiourea (XV) was prepared by the action of isothiocyanodimethyl ether on *p*-toluidine. This same thiourea was also formed smoothly when 1-paratolyl-2-isoamoxymethylthiourea (XVIII) and 1-paratolyl-2-ethoxymethylthiourea (XIX) were crystallized from methyl alcohol. Crystallization of 1-paratolyl-2-isoamoxymethylthiourea (XVIII) from ethyl alcohol gave 1-paratolyl-

---

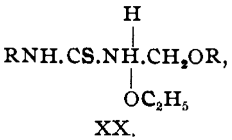
[1] Johnson and Guest, *Loc. cit.*

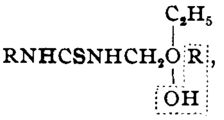
2-ethoxymethylthiourea (XIX), which is converted smoothly into the original isoamoxy derivative when warmed with isoamyl alcohol. These various transformations are represented by the following formulas:

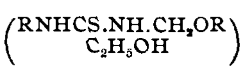


It is therefore possible, by application of this reaction, to prepare a whole series of ether-thioureas, $RNH.CSNH.CH_2OR'$, from one isothiocyanomethylether, $R'OCH_2.NCS$. In case it should be observed that certain primary, aliphatic halogen-ethers do not react, or perhaps react abnormally with potassium thiocyanate giving stable thiocyanates $R.SCN$, this reaction might be indispensable for the preparation of their corresponding thiourea derivatives.

It appears to the writers that the simplest explanation of these characteristic transformations of ether-thioureas is to assume the intermediate formation of unstable addition products, which then break down, giving a new thiourea and alcohol. Whether this involves an addition of the alcohol to nitrogen, as assumed by Decker, giving a compound XX, or an addition to the oxygen atom giving a carboxonium compound XXI, or thirdly a polymolecule XXII, we have at present no knowledge.


$$RNH.CS.N\overset{H}{\underset{OC_2H_5}{H}}.CH_2OR,$$
XX.


$$RNHCSNHCH_2\overset{C_2H_5}{O}\underset{OH}{R},$$
XXI.


$$\left(\begin{matrix}RNHCS.NH.CH_2OR\\C_2H_5OH\end{matrix}\right)$$
XXII.

The results which we have obtained do not support the theory advanced by Gadamer to explain the mechanism of the reaction of a cyclic alcoholate with alcohol. According to this interpretation, when an alcoholate reacts with alcohol, there is first a rupture of the bond between carbon and nitrogen of the alcoholate with intermediate formation of an aldehyde. In the case of an acyclic compound like 1-phenyl-2-ethoxymethylthiourea (XXIII), therefore, according to this explanation, formaldehyde (XXV) and phenylthiourea (XXIV) would be intermediate products of the reaction.

$$\underset{\text{XXIII.}}{C_6H_5NHCSNH.CH_2OR} \xrightarrow{H_2O} \underset{\text{XXIV.}}{C_6H_5NHCSNH_2} + \underset{\text{XXV.}}{CH_2O} + HO.R.$$

If a hydrolysis of this character takes place then one would expect to obtain the same ether-thiourea by simply dissolving phenylthiourea in an alcoholic solution of formaldehyde. The facts do not support such a conclusion. We obtained no evidence of the formation of ether-thioureas when phenylthiourea or *p*-tolylthiourea were crystallized repeatedly from a methylalcohol solution of formaldehyde. They separated unaltered, and melting constantly at 154° and 188°, respectively.

III. Experimental Part.

1. Crystallization from Methyl Alcohol: 1-Phenyl-2-methoxymethylthiourea, $C_6H_5NHCSNHCH_2OCH_3$.—This thiourea was formed smoothly by recrystallization of 1-phenyl-2-ethoxymethylthiourea (m. 125–6°) from methyl alcohol. It separated in prismatic crystals melting at 133° (Kjeldahl):

Calculated for $C_9H_{12}ON_2S$: N, 14.28; found, 14.28.

This same thiourea, melting at 133°, was also obtained by crystallizing 1-phenyl-2-isoamoxymethylthiourea (m. 109°) from methyl alcohol (Kjeldahl):

Calculated for $C_9H_{12}ON_2S$: N, 14.28; found, 14.10.

1-Paratolyl-2-methoxymethylthiourea, $CH_3.C_6H_4NHCSNHCH_2OCH_3$, was prepared by crystallizing 1-paratolyl-2-ethoxymethylthiourea (m. 120°) from methyl alcohol. It melted at 129° to a clear oil. The same thiourea was also formed smoothly when 1-paratolyl-2-isoamoxymethylthiourea was crystallized from methyl alcohol (Kjeldahl):

Calculated for $C_{10}H_{14}ON_2S$: N, 13.33; found, 13.42, 13.30.

2. Crystallization from Ethyl Alcohol.—(*a*) When 1-phenyl-2-isoamoxymethylthiourea (m. 109°) was dissolved in hot, absolute ethyl alcohol and the solution cooled, pure 1-phenyl-2-ethoxymethylthiourea separated and melted at 125–6°. A mixture of this thiourea and the thiourea made from aniline and isothiocyanomethylethyl ether melted at the same temperature (Kjeldahl):

Calculated for $C_{10}H_{14}ON_2S$: N, 13.33; found, 13.08.

(*b*) When 1-paratolyl-2-isoamoxymethylthiourea was crystallized from hot, absolute ethyl alcohol it was converted smoothly into 1-phenyl-2-ethoxymethylthiourea melting at 120° to a clear oil (Kjeldahl):

Calculated for $C_{11}H_{16}ON_2S$: N, 12.43; found, 12.40.

3. Crystallization from Isoamyl Alcohol.—(*a*) 1-Phenyl-2-ethoxymethylthiourea (m. 125–6°) was crystallized two times from isoamyl alcohol when it was completely changed to 1-phenyl-2-isoamoxymethylthiourea melting at 109°. A mixture of this thiourea and the thiourea prepared from isothiocyanomethylisoamyl ether and aniline melted at the same temperature (Kjeldahl):

Calculated for $C_{13}H_{20}ON_2S$: N, 11.11; found, 10.99.

(*b*) 1-Paratolyl-2-isoamoxymethylthiourea (m. 119°) was obtained when 1-paratolyl-2-ethoxymethylthiourea was crystallized from isoamyl alcohol (Kjeldahl):

Calculated for $C_{14}H_{22}ON_2S$: N, 10.52; found, 10.56.

NEW HAVEN, CONN.

PHENYL ETHER AND SOME OF ITS DERIVATIVES.

BY ALFRED N. COOK.

Received July 12, 1910.

Bromination of Phenyl and Tolyl Ethers.

The ethers employed were all prepared by distilling the aluminium salts of the corresponding phenols. While the yield of phenyl and metatolyl ether was good, the yield of the ortho- and paratolyl ether was so small that, in some instances, it was found difficult to obtain a sufficient amount of some of the bromine derivatives to purify sufficiently to yield very satisfactory results on analysis, which accounts for some instances given below where there is considerable difference between the results of analysis and the requirements of calculation. The best yield of phenyl ether was obtained by distilling aluminium phenolate with a sharp heat; but in case of the tolyl ethers, the best yield was obtained by distilling with a low heat. A sharp heat gives rise to a greater proportion of higher boiling substances and less of the ether.

On distilling some aluminium paracresolate with a sharp heat, a peculiar phenomenon was observed, which was not noted in connection with the distillation of any other aluminium salt of the phenols. Bright flashes of light followed one another in quick succession on the surface of the boiling and decomposing liquid. This recalls the fact noted in connection with the distillation of aluminium phenolate in the preparation of phenyl ether, that the escaping gases occasionally ignited spontaneously on coming in contact with the air. In the present case, however, the evolving gases had not yet come in contact with oxygen and the phenomenon could not have been due to combustion.

On distilling some aluminium paracresolate which had been kept for a couple of months in a bottle with a defective cork, through which air had gained access and acted upon the substance, it was found that it yielded paracresol and almost no paratolyl ether and higher boiling substances. It did not melt down as the freshly prepared substance does, even when highly heated. It was found to dissolve very readily in absolute alcohol, carbon disulphide and various other organic solvents. On adding a little water to the solution there was thrown down a voluminous gelatinous precipitate. Its action is therefore exactly analogous to that of aluminium phenolate to which air in limited amount has had access for some time, and which has been described in a previous paper. *An*