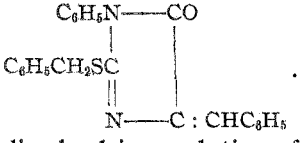
toin crystallized in characteristic prisms which melted at 240°. This melted unchanged with a known sample of 1-phenyl-2-thiohydantoin. The yield was 7 g., corresponding to 46%. It is a very significant fact that hydrogen sulfide was evolved freely in this decomposition. According to Anschutz[1] the hydrogen sulfide evolved in such reactions is destroyed at once by interaction with the mustard oil to give a thio-urea combination. This change is expressed as follows,

$$2R.NCS + H_2S = CS_2 + CS(NHR)_2.$$

In our experiment we obtained no evidence of the formation of the thio-urea derivative of amino-acetanilide. Apparently the mustard oil derivative immediately after formation is converted into the thiohydantoin. XVIII

$$2C_6H_5NHCOCH_2NCS + H_2S = CS_2 + CS(NHCH_2CONHC_6H_5)_2.$$

1-Phenyl-2-benzylmercapto-4-benzalhydantoin,



. — Five g. of 2-thio-4-benzalhydantoin was dissolved in a solution of sodium ethylate, prepared by dissolving 0.6 g. of sodium in 30 cc. of absolute alcohol. Then 5 g. of benzyl chloride was added slowly to the alkaline solution of the thiohydantoin. There was an immediate reaction and the solution became solid. After standing for 2 hours, the precipitate was filtered and then triturated with hot alcohol in order to separate the benzyl derivative from sodium chloride. This was then purified by crystallization from boiling alcohol and separated in the form of yellow needles melting at 178°.

Calc. for $C_{23}H_{18}ON_2S$: N, 7.57. Found: (Kjeldahl), 7.46, 7.74.

NEW HAVEN, CONN.

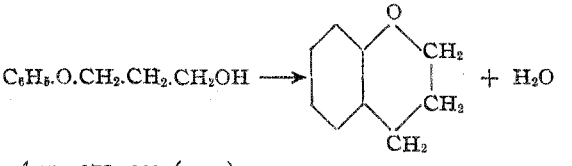
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS.]

HETEROCYCLIC COMPOUNDS OF *N*-ARYLAMINO ALCOHOLS.

BY R. E. RINDFUSZ AND V. L. HARNACK.

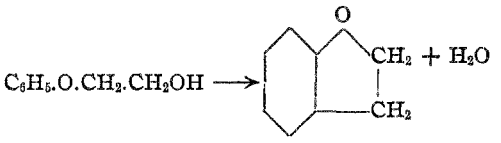
Received May 28, 1920.

A simple method has recently been published[2] for the preparation of chromanes and coumaranes according to the following reaction



[1] Anschutz, *Ann.*, **371**, 211 (1909).

[2] THIS JOURNAL, **41**, 665 (1919); **42**, 157 (1920).



The hydroxy ethers are easily prepared by treating phenol or its homologues either with trimethylene chlorohydrine or with ethylene chlorohydrine. They are dehydrated by treatment either with zinc chloride or with phosphorus pentoxide; the latter gives the better results. The present investigation was undertaken to see whether similar reactions could be applied to the preparation of analogous ring compounds of nitrogen.

The starting point in each case is aniline; but there is no reason for assuming that substituted anilines, phenylene diamines, naphthyl amines and similar compounds could not be used, although the products would be somewhat more complex.

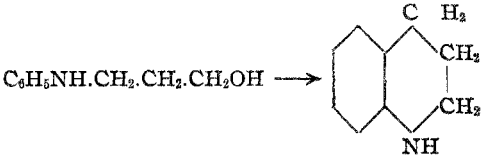
When aniline is treated either with trimethylene chlorohydrine or with ethylene chlorohydrine in the presence of sodium carbonate, 2 products are formed; one in which a single hydrogen of the amine group is substituted and the other in which both are replaced.

$$C_6H_5NH_2. \xrightarrow{Cl.CH_2.CH_2CH_2OH} C_6H_5NH.CH_2.CH_2.CH_2OH + C_6H_5N : (CH_2.CH_2.CH_2OH)_2$$

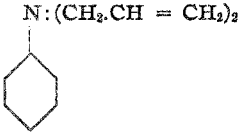
$$C_6H_5NH_2 \xrightarrow{Cl.CH_2.CH_2OH} C_6H_5NH.CH_2CH_2OH + C_6H_5N : (CH_2.CH_2OH)_2$$

These compounds in each case have widely differing boiling points and are easily separated and purified.

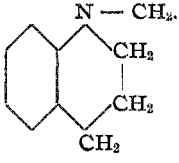
The products of dehydration of the first 2 compounds above are the simple rings one would expect from the analogous work in the chromane syntheses. Hydroxypropyl aniline gives the well known compound, tetrahydroquinoline



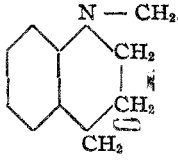
Dehydration of di-γ-hydroxy-propyl-aniline, however, offers a number of possible products as follows



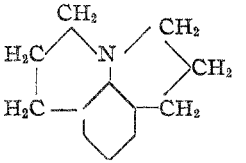
(I).



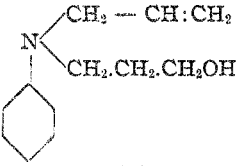
(II).



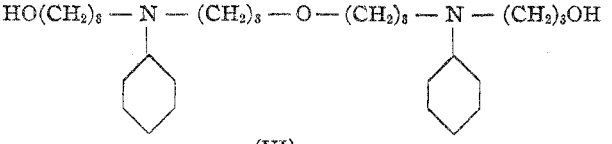
(III).



(IV).



(V).



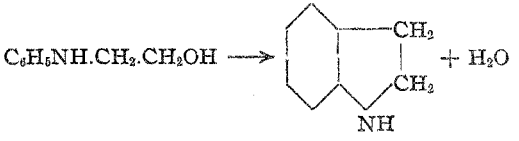
(VI).

Of these, III, V, and VI are eliminated by analysis since each of these formulas shows the loss of but one molecule of water. Formula I represents a known compound, but its constants do not agree with the product formed. A substance corresponding to Formula II was prepared by treating tetrahydroquiniline with allyl bromide and found to be a different substance. By elimination, IV alone is left. This represents julolidine, previously prepared by G. Pinkus[1] and J. von Braun[2] and the physical constants agree with those given.

In the case of the oxygen compounds referred to above, the dehydration of β-hydroxy-ethylphenyl ether, $C_6H_5—O—CH_2—CH_2OH$, forms coumarane, $C_6H_5\text{-}O—CH_2—CH_2$ in a manner exactly analogous to the preparation of the 6-membered ring compound chromane,

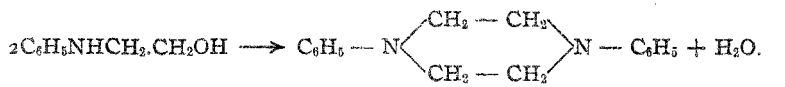
$$C_6H_5\text{-}O\text{-}CH_2—CH_2—CH_2.$$

However, with the nitrogen compounds, this is not the case. β-Hydroxy-ethyl-aniline would be expected to yield dihydro-indol, a liquid boiling at 220°.

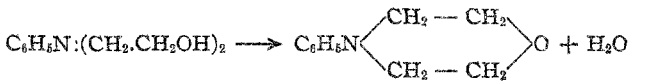


In the laboratory a very small amount of liquid did distill over, beginning at this temperature, but it was not enough to purify. The chief product of the reaction is a white crystalline solid melting at 160–162°. This is undoubtedly diphenyl piperazine for which melting points ranging from 157° to 164.5° have been reported.[3] It is formed by dehydration between 2 molecules. Thus

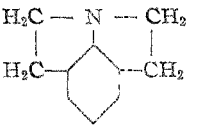
[1] *Ber.*, 25, 2801 (1892).
[2] *Ibid.*, 51, 1215 (1918).
[3] *Jahresb. Chem.*, 1858, 352; 1859, 388.



Again, the treatment of di-β-hydroxy-ethyl-aniline results in the formation of a 6-membered ring, this time by dehydration within the molecule.



This represents phenyl morpholin and is identified; first, by analysis, since the formation of the 5-membered ring compound by dehydration into the benzene ring would yield



with the elimination of 2 molecules of water; second, phenyl morpholine has been prepared by Knorr,[1] who observed a boiling point "around 270°" and a melting point of 53°. The product here found boiled at 165° to 170° under 45 mm. pressure and melted at 52°.

Thus, it is evident that these nitrogen compounds, unlike the analogous oxygen rings, show a marked preference for the formation of 6-membered rings rather than those of 5 atoms.

Experimental Part.

Preparation of γ-hydroxy-propyl-aniline, $C_6H_5.NH.CH_2.CH_2.CH_2OH$. —A mixture of 120 g. of aniline, 125 g. of trimethylene chlorohydrine and 125 g. of anhydrous sodium carbonate was refluxed for 3 or 4 hours. After filtering and washing the residue with ether, the liquid was distilled. The first reaction consisted of unchanged aniline; the desired product boiled at 192° under 30 mm. pressure. It is a viscous, lemon-colored liquid which turned red on standing. Yield, 92 g. or 67.5%. $[n]^{20}$ 1.502; d_{26}, 1.063.

Subs., 0.1660: CO_2, 263.4 cc. (25°, 744 mm.). Blank 0.0034 g. C.
Calc. for $C_9H_{13}ON$: C, 71.5. Found: 71.8.

Preparation of Di-γ-hydroxy-propyl aniline, $C_6H_5N = (CH_2CH_2CH_2OH)_2$.—A third fraction from the above distillation boiled at 241–2° under 25 mm. pressure. When first distilled, it was colorless but it turned red on standing. Yield, 45 g. or 25.3%. $[n]^{24}$, 1.565; d_{26}, 1.097.

Subs., 0.2308: CO_2, 345.3 cc. (24.1°, 745.1 mm.). Blank 0.0034 g. C.
Calc. for $C_{12}H_{19}O_2N$: C, 68.9. Found: 68.6.

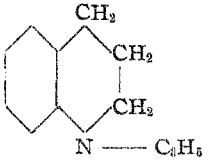
Tetrahydro Quinoline.—A solution of 90 g. of γ-hydroxy-propyl-aniline in 125 cc. xylene was refluxed with 40 g. of phosphorus pentoxide

[1] *Ber.*, 22, 2094 (1889).

for about an hour. This caused the entire mixture to become liquid. At this stage it was washed with sodium hydroxide and with water, dried and distilled. A yield of 17 to 18 g., about 22%, was obtained as a pale yellow liquid which boiled between 205° and 210° at 75 mm. pressure. $[n]^{24}$, 1.569; d_{24}, 1.051. The constants in the literature are, b. p., 251°, d_{25} 1.057.

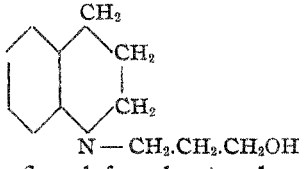
Julolidine.—To 22 g. of di-γ-hydroxy-propylaniline dissolved in hot xylene, 30 g. of phosphorus pentoxide was added. After this mixture had been warmed for a short time, vigorous action commenced and continued for several minutes without further application of heat. The mixture was heated under a reflux condenser for about 3 hours, which caused the pentoxide to become a viscous layer so that the xylene could be decanted easily. The residue was washed with ether and added to the xylene solution which was distilled. Yield, 2 g. or 11%. B. p. 170–173° at 31 mm. $[n]_{25}$, 1.568; d_{20}, 1.003. The boiling point given by von Braun[1] is 155–6° at 17 mm.

Subs., 0.2673: CO_2, 496.4 cc. (30.3°, 740.3 mm.).
Calc. for $C_{12}H_{15}N$: C, 83.2. Found: 83.3.

***N*-Allyl-tetrahydro-quinoline,** 

.—Six g. of tetrahydro-quinoline and the theoretical amount of allyl bromide were refluxed for 3 hours in the presence of anhydrous sodium carbonate.

The sodium bromide and excess sodium carbonate were separated and washed with ether. The filtrate and wash ether were then distilled. Yield, 4 g. B. p. 135° at 25 mm. $[n]^{24}$, 1.556; d_{24}, 1.024.

***N*-γ-Hydroxy-propyl-tetrahydro-quinoline,** 

Twenty-four g. of tetrahydro-quinoline was refluxed for about 3 hours with 17 g. of trimethylene chlorohydrine and an excess of anhydrous sodium carbonate. The mixture was then taken up in ether and distilled. This yielded 27 g. of a thick, viscous, yellow liquid, which turned red on standing. B. p. 227–9° at 18 mm. $[n]^{31}$, 1.561; d_{27}, 1.091.

Subs., 0.1571: CO_2, 263.8 cc. (26.6°, 743.3 mm.). Blank 0.0034 g. C.
Calc. for $C_{12}H_{17}ON$: C, 75.4. Found: 75.2.

Julolidine from *N*-γ-Hydroxy-propyl-tetrahydro-quinoline.—Julolidine may be prepared by the dehydration of the γ-hydroxy-propyl-tetrahydro-quinoline just described, but in the one run made, the yield was very

[1] *Ber.*, 51, 1215 (1918).

small. The dehydration was carried out in xylene as described above and evidently proceeds with difficulty since 3 hours' action on 27 g. of the hydroxy compound gave less than a gram of julolidine with a boiling point and refractive index the same as that given above.

β-Hydroxy-ethylaniline, $C_6H_5NH.CH_2.CH_2.OH$, **and Di-β-hydroxy-ethylaniline,** $C_6H_5N:(CH_2.CH_2.OH)_2$.—These compounds were prepared from aniline and ethylene chlorohydrine in a manner exactly analogous to that used for the γ-hydroxy-propyl derivatives described above. The constants observed for the first compound were b. p. 188°, at 30 mm.; $[n]^{24}$, 1.576; d_{24}, 1.101; and for the second, b. p. 228° at 15 mm.; m. p. 53.5–54°.

Diphenyl-piperazine, $C_6H_5.N\begin{matrix}CH_2-CH_2\\CH_2-CH_2\end{matrix}N.C_6H_5$.—To 65 g. of β-hydroxy-ethylaniline dissolved in xylene, a total of 25 g. of phosphorus pentoxide was added in 3 portions. After refluxing this mixture for an hour, the xylene layer was decanted and distilled. A small amount of a liquid, presumably dihydro-indol, came over between 220 and 270°. The remainder distilled around 245° at 30 mm. and crystallized as a white solid. After purification by solution in alcohol and precipitation with water several times, it melted at 160–162°. Yield, 5 g.

Phenyl-morpholin, $C_6H_5N\begin{matrix}CH_2-CH_2\\CH_2-CH_2\end{matrix}O$.—When di-β-hydroxy-ethylaniline was dehydrated with an amount of phosphorus pentoxide calculated to remove 2 molecules of water, most of the mixture carbonizes. However, when less pentoxide was used—30 g. in 2 portions to 50 g. of the aniline derivative in xylene—no carbonization took place. A water-clear liquid distilled between 165 and 170° at 45 mm.; this liquid turned red on standing and crystallized slowly. After recrystallization from alcohol, it melted at 52°.

Subs., 0.1500: CO_2, 247.2 cc. (26.9°, 743.3 mm.). Blank 0.0034 g. C.
Calc. for $C_{10}H_{13}ON$: C, 73.6. Found: 73.5.

Summary.

1. Cyclic nitrogen compounds may be formed by the dehydration of N-arylamino alcohols.

2. Where 6-membered rings may be so formed, the dehydration takes place in such a way as to close a side ring adjacent to the benzene nucleus.

3. Where a 5-membered ring would be formed as a side ring annealed to the benzene nucleus, a 6-membered ring outside is usually formed. This is unlike the behavior of analogous oxygen compounds.

4. The reaction on nitrogen compounds has not been carried out in enough cases to show that these inferences are general.

URBANA, ILL.