acid in chloroform to a solution of the base in the same solvent, the salt, m.p. 117–119°, was precipitated.

2-Amino-1-phenylpropane-1,3-diol.—2-Amino-1-phenyl-3-ethoxypropane-1-ol (1 g.) was dissolved in hydrobromic acid (48%, 7 ml.) and the solution was refluxed for one and a quarter hours. After cooling, the solution was separated by filtration from a small amount of resinous product which was formed and concentrated under reduced pressure. Water was then added to the residue and the solution was again concentrated under reduced pressure. This process was repeated three times to remove hydrobromic acid as completely as possible. Crude 2-amino-1-phenylpropane-1,3-diol hydrobromide was obtained as a reddish orange sirup. The product was then dissolved in concentrated sodium hydroxide and the solution was extracted with ethyl acetate. The extract was dried with anhydrous magnesium sulfate and evaporated to remove the solvent. Crude 2-amino-1-phenylpropane-1,3-diol was obtained as an oil in good yield. This base also could not be induced to form crystals. However, on addition of a solution of the base in chloroform to a solution of 3,5-dinitrobenzoic acid in the same solvent, the salt separated as a white precipitate which crystallized from an alcohol–ether mixture in white plates, m.p. 175–177°.

Anal. Calcd. for $C_{16}H_{17}N_3O_8$: N, 11.06. Found: N, 10.90.

2-Amino-1-phenyl-1-chloropropane-3-ol.—The oily 2-amino-1-phenylpropane-1,3-diol, prepared as described above was reconverted to sirupy hydrochloride through the addition of alcoholic hydrogen chloride followed by removal of the solvent. The hydrochloride was suspended in chloroform, and a slight excess of thionyl chloride in the same solvent was added. After standing overnight, the solution was evaporated *in vacuo* at room temperature to give a pale yellow solid. The solid was dissolved in absolute methanol and to this solution absolute ether was added. On keeping at room temperature, the 2-amino-1-phenyl-1-chloropropane-3-ol hydrochloride separated out as colorless plates in good yield. A sample was recrystallized from methanol ether and analyzed, m.p. 192–193°.

Anal. Calcd. for $C_9H_{13}Cl_2NO$: N, 6.37. Found: N, 6.43.

SAPPORO, HOKKAIDO, JAPAN

[CONTRIBUTION FROM THE COLLEGE OF PHARMACY, UNIVERSITY OF MICHIGAN]

Aminolysis Products of 1-Chloro-2-hydroxy-3-butene, 1-Hydroxy-2-chloro-3-butene and 1,2-Epoxy-3-butene

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1-Chloro-2-hydroxy-3-butene, 1-hydroxy-2-chloro-3-butene and 1,2-epoxy-3-butene reacted with aqueous solutions of secondary amines to form 1-dialkylamino-2-hydroxy-3-butenes. When 1-hydroxy-2-chloro-3-butene was allowed to react with anhydrous diethylamine, the principal reaction product was 1-hydroxy-4-diethylamino-2-butene, the formation of which was probably due to an allylic rearrangement. The basic olefinic alcohols were hydrogenated to the corresponding known basic alkanols. Various derivatives of the alcohols were prepared.

During a study of the preparation of certain basic alcohols, we allowed 1-chloro-2-hydroxy-3-butene (I) to react with 94% aqueous diethylamine and obtained 1-diethylamino-2-hydroxy-3-butene (III) in good yield. Compound III also was formed in about the same yield by interaction of 1-hydroxy-2-chloro-3-butene (IV) with 60% aqueous diethylamine. We believe that the formation of the basic butene III from IV, and possibly also from I, was *due to* the intermediate formation of 1,2-epoxy-3-butene (II).[3] In separate experiments it was found that the epoxybutene reacted with 94 and 60% aqueous diethylamine, respectively, to yield III. Incidentally, it was discovered that the speed of these reactions was greatly accelerated by the presence of a small amount of benzenesulfonic acid.

Hydrogenation of the basic butene III yielded 1-diethylamino-2-butanol (V), a product which has been prepared by other procedures.[4,5]

1-Chloro-2-hydroxy-3-butene (I) reacted with aqueous dimethylamine and with aqueous piperidine, in the same manner as with diethylamine, to form 1-dimethylamino- and 1-piperidino-2-hydroxy-3-butene, respectively. The 1-dimethylamino-2-hydroxy-3-butene was hydrogenated to form 1-dimethylamino-2-butanol which was converted by thionyl chloride into 1-dimethylamino-2-chlorobutane.

When 1-hydroxy-2-chloro-3-butene (IV) was allowed to react with anhydrous diethylamine, the principal reaction product was 1-hydroxy-4-diethylamino-2-butene (VI) but a small amount of III was also formed.

The hydrobromides of III and VI were obtained only in the form of oils, but the dibromide hydrobromides (X and X′) were isolated in crystalline form.

Initially, we considered the product obtained from IV and anhydrous diethylamine to be a compound represented by structure VI′. This substance (VI′), upon hydrogenation, would yield 2-diethylaminobutanol (VII′) while a compound which possessed structure VI would be converted into 4-diethylamino-butanol (VII). Both alcohols VII[6–9] and VII′[5,10] have been obtained by other procedures. The basic alcohol which we obtained possessed properties which correspond to those described for VII.

(1) This paper represents part of a dissertation submitted by J. H. Biel in partial fulfillment of the requirements for the Ph.D. degree in the University of Michigan, 1947.

(2) Frederick Stearns and Co. Fellow.

(3) F. C. Whitmore, H. S. Mosher, D. P. Spalding, R. B. Taylor, G. W. Moersch and W. H. Yanko (THIS JOURNAL, **68**, 531 (1946)) reported that 1-hydroxy-2,3-dibromopropane and piperidine reacted to form 1-hydroxy-2,3-dipiperidino-1,3-dipiperidino-2-hydroxypropane, and suggested that the latter substance probably was produced through the intermediate formation of 1,2-epoxy-3-bromopropane.

(4) J. Houben and K. Führer, *Ber.*, **47**, 75 (1915).

(5) W. T. Olson and F. M. Whitacre, THIS JOURNAL, **65**, 1019 (1943).

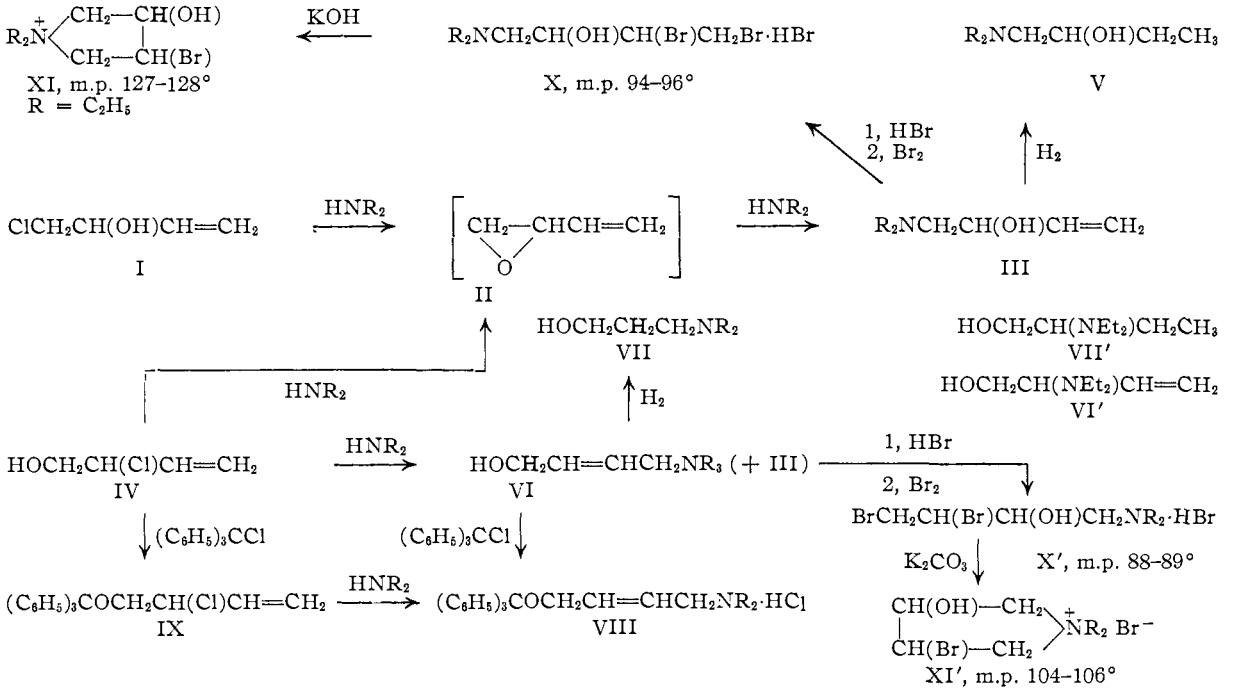
(6) O. J. Magidson and I. T. Strukov, *Arch. Pharm.*, **271**, 569 (1933).

(7) W. B. Burnett, R. L. Jenkins, C. H. Peet, E. E. Dreger and R. Adams, THIS JOURNAL, **59**, 2248 (1937).

(8) British Patent 565,745; *C. A.*, **40**, 5534 (1946).

(9) A. W. D. Avison, *J. Appl. Chem.*, **1**, 469 (1951); *C. A.*, **46**, 11109 (1952).

(10) E. Rajner, E. Cerknovnikow and P. Stern, *Arch. Pharm.*, **281**, 78 (1943).



Compound IV was allowed to react with anhydrous dimethylamine, and the basic butene (VI, R = CH_3) obtained was hydrogenated. The methiodide of the basic alcohol which was formed (VII, R = CH_3) melted at 131–132°; the melting point of the methiodide of 4-dimethylaminobutanol was reported to be 134°.[11] The formation of a 1-hydroxy-4-dialkylamino-2-butene (VI) instead of a 1-hydroxy-2-dialkylamino-3-butene (VI') in the interaction of IV with an anhydrous amine can be explained by the assumption of an allylic rearrangement.

Compound VI reacted with triphenylchloromethane to form a triphenylmethyl ether (VIII). The same ether was obtained by conversion of IV into its triphenylmethyl ether (IX) and treatment of the ether with diethylamine. We believe that an allylic rearrangement took place during the interaction of IX with the amine.

The hydrobromide of III was converted by bromine into a dibromide hydrobromide (X) (m.p. 94–96°), and the latter substance was treated with the amount of alcoholic potassium hydroxide required for the liberation of the base. After removal of the alcohol, a crystalline, water-soluble, ether-insoluble product (m.p. 127–128°) was obtained. The assumption that this substance was 1,1-diethyl-3-hydroxy-4-bromopyrrolidinium bromide (XI), formed by spontaneous cyclization of the base, received support from the fact that the product contained one ionizable bromine atom. Nitrogen and total bromine analyses, as well as a molecular weight determination, furnished data which corresponded to that calculated for XI.

Compound VI was converted into the hydrobromide and then into the dibromide hydrobromide (X') (m.p. 88–89°; mixture of X and X', mixed m.p. 75–87°). We believe that during the conversion of VI into the hydrobromide, an allylic rearrangement may have taken place, and that the dibromide possessed structure X'. When an aqueous solution of X' was treated with potassium carbonate, the oily, ether-soluble, water-insoluble base precipitated. After some time, this base became crystalline, ether-insoluble and water-soluble, a change which was thought to be due to its spontaneous cyclization to 1,1-diethyl-3-bromo-4-hydroxypyrrolidinium bromide (XI') (m.p. 104–106°). The percentages of total and ionizable bromide found by analysis, and also a molecular weight determination, supported this assumption. Our explanation of the observed phenomena is that X and X', as well as XI and XI', represent diastereoisomeric modifications.

Various hydrohalide and quaternary salts, esters and ethers which were prepared from the alcohols are listed in Table I.

Experimental

1-Dimethylamino-2-hydroxy-3-butene (III, R = CH_3).—A mixture of 23.4 g. of 1,2-epoxy-3-butene,[12] 85.0 g. of dimethylamine hydrochloride and 20 cc. of water was placed in a pressure bottle, cooled in an ice-bath, and 40 g. of sodium hydroxide, dissolved in 40 cc. of water, was added. The mixture was heated on a steam-bath for 5 hours, filtered, and the filtrate was made strongly alkaline with solid sodium hydroxide. The aqueous layer was extracted with ether and the extract was mixed with the organic layer. The dried mixture was distilled, b.p. 67–68° (32 mm.), yield 33.0 g. (81%).

Anal. Calcd. for $C_6H_{13}ON$: N, 12.17. Found: N, 11.96.

After addition of the calculated amount of alcoholic hydrogen bromide to the base and removal of the solvent, the hydrobromide was obtained, m.p. 90–92° after recrystallization from acetone.

Anal. Calcd. for $C_6H_{14}ONBr$: Br, 40.70. Found: Br, 40.95.

1-Dimethylamino-2-hydroxybutane (V, R = CH_3).—The butene (63.0 g.), dissolved in a mixture of 40 cc. of water

(11) R. Lukes and J. Preucil, *Coll. Czechoslov. Chem. Commun.*, **10**, 394 (1938); *C. A.*, **33**, 983 (1939); *Chem. Zentr.*, **110**, I, 114 (1939).

(12) Obtained from the Pittsburgh Plate Glass Company, Columbia Chemical Division.

TABLE I
DERIVATIVES OF BASIC ALCOHOLS

	M.p., °C.	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Halogen, % Calcd.	Halogen, % Found
1. $(CH_3)_2NCH_2CH(OH)CH{=}CH_2$[e]						
a, Hydrobromide	90–92	$C_6H_{14}ONBr$			40.76	40.96
b, Methochloride	141–143	$C_7H_{16}ONCl$			21.41	21.32
c, Acetate	67–73[a]	$C_8H_{15}O_2N$	8.92	8.86		
d, Acetate methochloride	164–166	$C_9H_{18}O_2NCl$			17.10	17.10
e, Acetate benzylchloride	136–138	$C_{15}H_{22}O_2NCl$			12.52	12.50
f, Diphenylacetate hydrochloride	154–156	$C_{20}H_{24}O_2NCl$			10.27	10.26
2. $(CH_3)_2NCH_2CH(OH)CH_2CH_3$						
a, Methochloride	177–178	$C_7H_{18}ONCl$			21.20	21.10
b, Acetate	82–84[d]	$C_8H_{17}O_2N$	8.80	8.54		
c, Acetate methochloride	150–152	$C_9H_{20}O_2NCl$			16.94	16.86
3. $(C_2H_5)_2NCH_2CH(OH)CH{=}CH_2$[b]						
a, Hydrochloride	86–88	$C_8H_{15}ONCl$	7.79	7.42	19.77	19.57
b, Methiodide	103–104	$C_9H_{20}ONI$			44.50	44.47
c, Allobromide	123–126	$C_{11}H_{22}ONBr$			30.28	30.38
d, Diphenylacetate hydrochloride	100–105	$C_{22}H_{28}O_2NCl$	3.74	3.58	9.49	9.20
4. $(C_2H_5)_2NCH_2CH(OH)CH_2CH_3$						
a, Hydrobromide	83–84	$C_8H_{20}ONBr$			35.40	35.59
b, Diphenylacetate hydrochloride	111–113	$C_{22}H_{30}O_2NCl$			9.45	9.45
c, *p*-Nitrobenzoate hydrochloride	149–150	$C_{15}H_{23}O_4N_2Cl$			10.74	10.90
d, *p*-Aminobenzoate hydrochloride	168–169	$C_{15}H_{25}O_2N_2Cl$	9.32	9.17	11.82	11.98
5. $C_5H_{10}NCH_2CH(OH)CH{=}CH_2$[b]						
a, Diphenylacetate hydrochloride	179–181	$C_{23}H_{28}O_2NCl$	3.63	3.61	9.19	9.20
6. $(CH_3)_2NCH_2CH{=}CHCH_2OH$						
a, Methochloride	118–119	$C_7H_{16}ONCl$			21.45	21.32
b, Acetate	36–37[a]	$C_8H_{15}O_2N$	8.92	8.81		
c, Acetate methochloride	95–97	$C_9H_{18}O_2NCl$			17.10	17.13
7. $(CH_3)_2NCH_2CH_2CH_2CH_2OH$						
a, Methochloride	153–154	$C_7H_{18}ONCl$			21.20	21.14
b, Methiodide	131–132[c]					
c, Acetate	73–74[a]	$C_8H_{17}O_2N$	8.80	8.40		
d, Acetate methochloride	117–118	$C_9H_{20}O_2NCl$			16.94	16.95
8. $(C_2H_5)_2NCH_2CH{=}CHCH_2OH$						
a, Hydrobromide	82–84	$C_8H_{18}ONBr$	6.25	6.12	35.68	35.40
b, Methiodide	58–60	$C_9H_{20}ONI$			44.50	44.27
c, Benzhydryl ether hydrobromide	88–89	$C_{21}H_{28}ONBr$			20.49	20.56
d, Diphenylacetate hydrochloride	92–94	$C_{22}H_{28}O_2NCl$	3.74	3.66	9.49	9.49
e, Diphenylacetate hydrobromide	121–122	$C_{22}H_{28}O_2NBr$			19.10	19.00
9. $(C_2H_5)_2NCH_2CH_2CH_2CH_2OH$						
a, Diphenylacetate hydrochloride	113–115	$C_{22}H_{30}O_2NCl$			9.45	9.65
10. $C_5H_{10}NCH_2CH{=}CHCH_2OH$						
a, Methiodide	84–86	$C_{12}H_{20}ONI$			42.70	42.84

[a] Boiling point at 15 mm. [b] C_5H_{10} = piperidino. [c] Ref. 11, m.p. 134°. [d] B.p. at 33 mm. [e] Compounds 1a, 1f, 3b, 3c (triturated), 4b, 4c, 4d (refluxed with), 6c, 8a, 8b (triturated) and 9a were recrystallized from reagent acetone; compounds 1b, 2a, 2c, 5a, 7b and 7d from acetone–isopropyl alcohol; compounds 1d and 10a from isopropyl alcohol; compounds 1e, 3a, 3d, 4a, 8c and 8d from acetone–ether; compound 6a from isopropyl alcohol–ether; compound 7a was washed with dry ether.

and 48 cc. of concd. hydrochloric acid, was hydrogenated in the presence of 1 g. of platinum oxide catalyst under an initial pressure of 44 pounds. The mixture was filtered, the filtrate was saturated with sodium chloride and extracted with ether to remove by-products. After addition of solid sodium hydroxide and extraction with ether, 50.0 g. (80%) of product was obtained; b.p. 71–73° (42 mm.).

Anal. Calcd. for $C_6H_{15}ON$: N, 11.97. Found: N, 11.90.

1-Dimethylamino-2-chlorobutane Hydrochloride.—A mixture of 5.8 g. of the butane, 40 cc. of chloroform and 11.9 g. of thionyl chloride was refluxed for 3 hours, the liquids were removed by distillation and the residue was rubbed under petroleum ether whereupon it became crystalline. The material was dissolved in a mixture of acetone and isopropyl alcohol, the solution was boiled with Norite, filtered and the solvents were removed. The colorless, crystalline residue weighed 5.1 g. (60%), m.p. 178–179°.

Anal. Calcd. for $C_6H_{15}NCl_2$: Cl^-, 20.64. Found: Cl^-, 20.68.

1-Diethylamino-2-hydroxy-3-butene (III, R = C_2H_5) **(A).**—A mixture of 10.0 g. of 1-chloro-2-hydroxy-3-butene (I),[13] 15.3 g. of diethylamine and 1 cc. of water[14] was refluxed for 9 hours. The unchanged amine and water were removed under reduced pressure, 50 cc. of water and then concentrated hydrochloric acid were added until the mixture was acidic. After extraction with ether, the acidic solution was made strongly alkaline with solid sodium hydroxide and the oily product was extracted with ether. After removal of the solvent from the dried extract, the product boiled at 71–72° (19 mm.), yield 11.0 g. (81%), $n^{20}D$ 1.4445.

(13) R. G. Kadesch, THIS JOURNAL, **68**, 41 (1946).

(14) In an experiment in which 20 cc. of absolute alcohol was used instead of water, the yield of product was only 46%.

Anal. Calcd. for $C_8H_{17}ON$: N, 9.78. Found: N, 9.47.

An ethereal solution of the base was treated with the calculated amount of ethereal hydrogen chloride. The hydrochloride melted at 86–88° after recrystallization from ether–acetone.

Anal. Calcd. for $C_8H_{17}ONCl$: N, 7.79; Cl^-, 19.77. Found: N, 7.42; Cl^-, 19.57.

(B).—1,2-Epoxy-3-butene (II, 14.0 g.), 2 cc. of water and 28.6 g. of diethylamine were refluxed for 15 hours. Upon distillation, 24.0 g. (85%) of product was obtained; b.p. 71–72° (19 mm.).

When the experiment was repeated with the addition of 1.0 g. of benzenesulfonic acid, an 85% yield was obtained after the mixture had been refluxed for only 3 hours.

(C).—A mixture of 26.6 g. of 1-hydroxy-2-chloro-3-butene (IV),[15] 73.0 g. of diethylamine and 50 cc. of water was heated in a pressure bottle for 7 hours on a steam-bath and then treated as in method A; b.p. 82–84° (28 mm.), yield 29.0 g. (81%).

The methiodide, prepared in ethereal solution, melted at 103–104° after recrystallization from acetone.

Anal. Calcd. for $C_9H_{20}ONI$: I^-, 44.50. Found: I^-, 44.47.

The allobromide melted at 123–126° after trituration with acetone.

Anal. Calcd. for $C_{11}H_{22}ONBr$: Br^-, 30.28. Found: Br, 30.38.

1-Diethylamino-2-butanol (V).—Compound III (35.7 g.) was hydrogenated in the manner described above; yield 29.0 g. (80%), b.p. 70–72° (17 mm.).

The hydrobromide was obtained by the use of the calculated amount of alcoholic hydrogen bromide; m.p. 83–84° after recrystallization from acetone–ether.

Anal. Calcd. for $C_8H_{20}ONBr$: Br, 35.40. Found: Br, 35.59.

1-Piperidino-2-hydroxy-3-butene (III, R_2N = piperidino).—A mixture of 35.0 g. of 1,2-epoxy-3-butene, 85.0 g. of piperidine, 2.5 g. of benzenesulfonic acid and 3 cc. of water was refluxed for 4 hours; yield 67.0 g. (86%), b.p. 67–68° (4 mm.).

Anal. Calcd. for $C_9H_{17}ON$: N, 9.02. Found: N, 8.88.

4-Dimethylamino-2-butene-1-ol (VI, R = CH_3).—1-Hydroxy-2-chloro-3-butene (42.8 g.) was placed in a pressure bottle, cooled with Dry Ice and acetone, and 54.0 g. of cold dimethylamine was added. After 12 hours at room temperature, the mixture was heated at 80° for 2 days. The precipitated dimethylamine hydrochloride was removed and the residue was distilled; b.p. 72–73° (4 mm.), yield 21.0 g. (46%), $n^{25}D$ 1.4633.

Anal. Calcd. for $C_6H_{13}ON$: N, 12.17. Found: N, 12.05.

The fraction which boiled at 33–36° (4 mm.) (19.0 g.) probably was 1-dimethylamino-2-hydroxy-3-butene.

4-Dimethylaminobutanol (VII, R = CH_3).—Hydrogenation of 23.0 g. of 4-dimethylamino-2-butene-1-ol in the manner described above yielded 15.0 g. (64%) of product, b.p. 68–70° (6 mm.),[16,17] $n^{20}D$ 1.4416.

4-Dimethylaminobutyl Chloride Hydrochloride.—The required alcohol (5.8 g.) and thionyl chloride were refluxed for 1.5 hours. The yield of crude product was 8.5 g., m.p. 110–112°[18] after recrystallization from acetone.

Anal. Calcd. for $C_6H_{15}NCl_2$: Cl^-, 20.64. Found: Cl^-, 20.85.

4-Diethylamino-2-butene-1-ol (VI).—A mixture of IV (60 g.) and 120.0 g. of anhydrous diethylamine was refluxed on a steam-bath for 17 hours. The mixture was treated as in method A. The product boiled at 86–89° (4 mm.), yield 57.0 g. (70%), $n^{20}D$ 1.4700.

Anal. Calcd. for $C_8H_{17}ON$: C, 67.13; H, 11.88; N, 9.78. Found: C, 66.80; H, 11.86; N, 9.35.

Prepared with the use of the calculated amount of alcoholic hydrogen bromide, the hydrobromide melted at 82–84° after recrystallization from acetone.

Anal. Calcd. for $C_8H_{18}ONBr$: N, 6.25; Br^-, 35.68. Found: N, 6.12; Br^-, 35.40.

The methiodide melted at 58–60° after trituration with acetone.

Anal. Calcd. for $C_9H_{20}ONI$: I^-, 44.50. Found: I^-, 44.27.

4-Diethylaminobutanol (VII).—Reduced in the described manner, 28.6 g. of VI yielded 27.0 g. (93%) of product, b.p. 102–104° (16 mm.),[19] $n^{20}D$ 1.4475.

Anal. Calcd. for $C_8H_{19}ON$: N, 9.65. Found: N, 9.78.

1-Triphenylmethoxy-2-chloro-3-butene (IX).—A mixture of 5.3 g. of IV, 4.1 cc. of pyridine, 13.9 g. of triphenylchloromethane and 50 cc. of benzene was refluxed for 12 hours. After filtration of the precipitated pyridine hydrochloride, the benzene was removed by distillation, ether was added to the residue, the mixture was filtered and the solvent was removed from the filtrate. The residue was recrystallized from petroleum ether (60–70°); yield 11.3 g., m.p. 84–86°.

Anal. Calcd. for $C_{23}H_{21}OCl$: Cl, 10.18. Found: Cl, 9.68.

1-Triphenylmethoxy-4-diethylamino-2-butene Hydrochloride (VIII) (A).—Compound IX (10.5 g.), 22.2 g. of diethylamine and 40 cc. of benzene were heated in a pressure bottle for 5 hours on a steam-bath. The precipitated diethylamine hydrochloride was removed by filtration and the filtrate was decolorized with charcoal. After removal of the solvent, the oil residue was mixed with 100 cc. of ether, filtered and the solution was treated with the calculated amount of alcoholic hydrogen chloride; the precipitated salt (8.0 g., 63.5%) was recrystallized from acetone–isopropyl alcohol; m.p. 189–190°.

Anal. Calcd. for $C_{27}H_{32}ONCl$: N, 3.32; Cl^-, 8.43. Found: N, 3.22; Cl^-, 8.34.

(B).—Compound VI (7.1 g.), 13.9 g. of triphenylchloromethane and 50 cc. of benzene were refluxed for 2 hours. The precipitate was recrystallized from acetone–isopropyl alcohol; m.p. and mixed m.p. 189–190°.

4-Piperidino-2-butene-1-ol.—Fifty grams of IV and 128.0 g. of piperidine were heated on a steam-bath for 1 hour. After filtration of the precipitated piperidine hydrochloride, the filtrate was fractionated, b.p. 102–105° (3 mm.), yield 35.0 g.

Anal. Calcd. for $C_9H_{17}ON$; N, 9.02. Found: N, 8.60.

The fraction (21.0 g.) which boiled at 68–102° (3 mm.) probably contained the isomeric 1-piperidino-2-hydroxy-3-butene.

1-Diethylamino-2-hydroxy-3,4-dibromobutane Hydrobromide (X and X').—To 3.4 g. of III, dissolved in 25 cc. of absolute ethanol, there was added 18 cc. of 1.38 *N* alcoholic hydrogen bromide while the solution was cooled and stirred. After removal of the alcohol under reduced pressure, the oily hydrobromide was dissolved in 30 cc. of chloroform. The solution was stirred and kept below 20° while 3.8 g. of bromine, dissolved in 30 cc. of chloroform, was added during the course of 4 hours. The solvent was removed, the residue was dissolved in 35 cc. of dry acetone, the solution was refluxed with charcoal, filtered and 50 cc. of dry ether was added to the filtrate. After the mixture had been cooled in a refrigerator, the precipitate X melted at 94–96° after recrystallization from acetone–ether; yield 5.3 g. (63%).

Anal. Calcd. for $C_8H_{16}ONBr_3$: N, 3.65; (total) Br, 62.43; Br^-, 20.82. Found: N, 3.43; (total) Br, 61.47; Br^-, 21.38.

The experiment was repeated with the use of 3.4 g. of VI, but in this instance the bromine was added during the course of 8 hours. The dibromide hydrobromide (X') which precipitated weighed 4.8 g. (52%), m.p. 88–89° after recrystallization from acetone–ether.

Anal. Calcd. for $C_8H_{18}ONBr_3$: N, 3.65; (total) Br, 62.43; Br^-, 20.82. Found: N, 3.60; (total) Br, 62.01; Br^-, 20.84.

1,1-Diethyl-3-hydroxy-4-bromopyrrolidinium Bromide (XI and XI').—To 11.5 g. of X, dissolved in 50 cc. of absolute ethanol, there was added 1.7 g. of potassium hydroxide, dissolved in 10 cc. of the same solvent, while the tempera-

(15) A. A. Petrov, *J. Gen. Chem. U. S. S. R.*, **11**, 991 (1941); *C. A.*, **37**, 1699 (1943); see also ref. 12.

(16) Reference 11, b.p. 187°.

(17) E. Szarvasi (*Bull. soc. chim. France*, 647 (1949)), b.p. 81–84° (12 mm.).

(18) British Patent 690,576 (*C. A.*, **48**, 7046 (1954)), m.p. 112–115°.

(19) Reference 6, b.p. 90–92° (7–9 mm.); ref. 8, b.p. 92–97° (11 mm.); ref. 9, b.p. 96° (12 mm.).

ture was maintained below 10°. The precipitated potassium bromide was filtered and 100 cc. of dry ether was added to the filtrate. After the mixture had been cooled, the water-soluble precipitate XI (7.3 g., 80%) melted at 127–128° dec. after recrystallization from isopropyl alcohol.

Anal. Calcd. for $C_8H_{17}ONBr_2$: N, 4.62; (total) Br, 52.75; Br^-, 26.38; mol. wt., 303. Found: N, 4.56; (total) Br, 52.70; Br^-, 26.05; mol. wt., (water) 301.

A solution prepared from 19.2 g. of X′ and 30 cc. of water was made strongly alkaline with potassium carbonate and the precipitated oily base was extracted with ether. The extract was dried over magnesium sulfate and the solvent was removed at room temperature under reduced pressure. The water-insoluble oil, after about 12 hours, became semi-solid and completely water soluble. The product XI′ turned crystalline when rubbed under acetone and melted at 104–106° after recrystallization from isopropyl alcohol–ether, yield 7.0 g.

Anal. Calcd. for $C_8H_{17}ONBr_2$: (total) Br, 52.75; Br^-, 26.38; mol. wt., 303. Found: (total) Br, 52.40; Br^-, 26.41; mol. wt. (water), 301.

Derivatives of the basic alcohols (Table I) were prepared by the following procedures.

Hydrobromides were obtained by addition of 37 cc. of 1.35 *M* alcoholic hydrogen bromide to 0.05 mole of the required alcohol. The solvent was removed under reduced pressure and the residue was rubbed under dry ether.

Methochlorides were formed when a mixture of 0.24 mole of the alcohol, 0.24 mole of methyl chloride and 200 cc. of chloroform was heated for 12 hours on a steam-bath. The solvent was removed and the residue was triturated with ether.

Methiodides were prepared from 0.025 mole of the alcohol, 0.25 mole of methyl iodide and 30 cc. of dry ether. After 2 days at room temperature, the precipitate was recrystallized.

In order to obtain the acetates, 0.60 mole of acetyl chloride was added (through a condenser), during a 30-minute period, to a solution of 0.30 mole of the alcohol in 75 cc. of chloroform at such a rate that the mixture just boiled. The chloroform was removed by distillation and the residue was dissolved in water. The aqueous solution was made alkaline with potassium carbonate, extracted with ether and the extract was dried with anhydrous potassium carbonate. The solution was then fractionated.

Acetate methochlorides were synthesized by heating a mixture of 0.12 mole of the acetate, 0.20 mole of methyl chloride and 200 cc. of chloroform in a pressure bottle for 12 hours on a steam-bath. The solvent was removed and the residue recrystallized. Compound 1d was obtained also by heating 3.9 g. of compound 1b and 18 g. of acetic anhydride at 100° for 8 hours. The reaction mixture was poured into dry ether and the oily precipitate was triturated with ether; m.p. 164–166°.

Compound 1e precipitated when 7.9 g. of 1c, 30.0 g. of benzyl chloride and 25 cc. of dry ether were refluxed for 12 hours.

Diphenylacetate hydrochlorides were obtained when a mixture of 0.05 mole of the alcohol, 0.05 mole of diphenylacetyl chloride and 50 cc. of reagent acetone was refluxed for 12 hours. After removal of the solvent, the ester salt was recrystallized.

A mixture of 14.5 g. of the required alcohol, 18.6 g. of *p*-nitrobenzoyl chloride and 50 cc. of reagent acetone was refluxed for 2 hours and the precipitated *p*-nitrobenzoate hydrochloride (4c) was filtered and recrystallized.

When 16.5 g. of the hydrochloride (4c) was hydrogenated under an initial pressure of 45 pounds in the presence of 100 cc. of absolute ethanol and 0.5 g. of platinum oxide catalyst, the *p*-aminobenzoate salt (4d) was obtained after filtration and removal of the ethanol.

The benzhydryl ether hydrochloride (8c) was obtained by refluxing a mixture of 7.1 g. of the alcohol, 12.3 g. of benzhydryl bromide and 25 cc. of pyridine for 5 hours. Water and then potassium carbonate were added, the mixture was extracted with ether and the extract was dried with anhydrous potassium carbonate. The ether and pyridine were removed by distillation and the residue was fractionated; b.p. 185–188° (3 mm.). When the base was dissolved in ether and the calculated amount of alcoholic hydrogen bromide was added, the crystalline hydrobromide precipitated.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY]

Rearrangement of 2,4,6-Trimethylbenzyltrimethylammonium Ion by Sodium Amide to Form an *exo*-Methylenecyclohexadieneamine and its Reactions[1]

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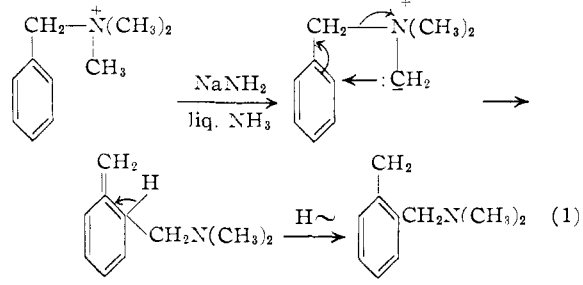
The 2,4,6-trimethylbenzyltrimethylammonium ion was found to undergo with sodium amide in liquid ammonia the first phase of the *ortho* substitution rearrangement to give an *exo*-methylenecyclohexadieneamine. This alicyclic compound underwent thermal isomerization to form β-mesitylethyldimethylamine, and reacted with electrophilic and nucleophilic reagents to produce certain aromatic compounds and by-products. The latter reagents formed an intermediate alicyclic product. Mechanisms for these reactions are discussed. The *exo*-methyleneamine also was hydrogenated.

The *ortho* substitution rearrangement of benzyl type quaternary ammonium ions by sodium amide in liquid ammonia to form tertiary amines[3] has been assumed to involve the intermediate formation of not only a carbanion but also an *exo*-methylenecyclohexadieneamine. The latter intermediate undergoes a prototropic change resulting in the aromatic product. The reaction may be illustrated by the rearrangement of the benzyltrimethylammonium ion to *o*-methylbenzyldimethylamine (equation 1).[3,4]

Although this reaction would be difficult to stop at the *exo*-methylene stage, the corresponding reaction of the 2,4,6-trimethylbenzyltrimethylammonium ion (I) was found in the present investigation[5]



(1)

(1) Supported in part by the National Science Foundation.

(2) Monsanto Chemical Co. Fellow, 1955–1956.

(3) S. W. Kantor and C. R. Hauser, THIS JOURNAL, **73**, 4122 (1951).

(4) The ionization of a methyl hydrogen shown in this equation may be preceded by that of the more reactive benzyl hydrogen; see ref. 3.

(5) For a preliminary report on this reaction see C. R. Hauser and D. N. Van Eenam, THIS JOURNAL, **78**, 5698 (1956).