# Ortho-Substitution Rearrangement *vs.* Elimination Reaction of Certain Benzyl-Type Quaternary Ammonium Ions with Sodium Amide[1]

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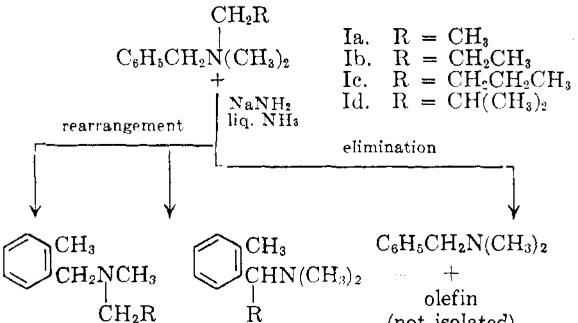
*Received December 26, 1961*

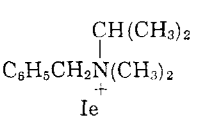
Certain benzyldimethylalkylammonium ions having β-hydrogen underwent both the ortho-substitution rearrangement and an elimination reaction with sodium amide in liquid ammonia to form a mixture of two isomeric rearranged amines and benzyldimethylamine. The relative extents of these two types of reaction and the ratios of the two isomeric amines were determined by vapor phase chromatography. The structures of all of the main isomers and of one of the minor isomers from the rearrangement were established by independent synthesis. Evidence was obtained that the elimination reaction involved intramolecular elimination within the benzyl carbanion. The benzylisobutylethylmethylammonium ion underwent mainly elimination with sodium amide in liquid ammonia and with butyllithium in ether.

It has previously been observed[2] that the benzyldimethyl-*n*-propylammonium ion (Ib) undergoes simultaneously two different types of reaction with sodium amide in liquid ammonia. One type is the ortho-substitution rearrangement, giving mainly tertiary amine IIb, and the other is an elimination reaction, forming benzyldimethylamine (Scheme A).

Scheme A

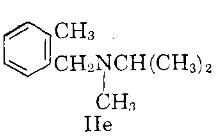


It has now been found that quaternary ammonium ions Ia, Ic, and Id likewise exhibit these two different types of reaction, and that the four quaternary ions Ia–d afford rearrangement products consisting not only of the corresponding tertiary amines IIa–d but also tertiary amines IIIa–d. Similarly, quaternary ion Ie afforded a mixture of rearranged amines IIe and IIIe and also benzyldimethylamine.

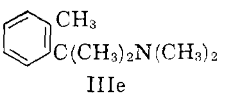


$$C_6H_5CH_2\overset{\displaystyle CH(CH_3)_2}{\overset{|}{N}}(CH_3)_2\ \overset{+}{}$$

Ie



IIe



IIIe

These reactions were generally effected by addition of the quaternary salt to three molecular equivalents of the reagent, although addition of the reagent to one equivalent of quaternary salt Ia (inverse addition procedure) afforded essentially the same proportion of rearranged amines IIa and IIIa to benzyldimethylamine. In Table I are summarized the proportions of rearrangement to elimination products, the calculated yields of the mixture of rearrangement products and of benzyldimethylamine, and the ratios of amines of types II and III.

The relative extents of the two types of reaction were determined by vapor phase chromatography.[3] A sample of the crude amine product was passed through a short, nonselective column which separated benzyldimethylamine from the rearrangement isomers but which did not separate these isomers. The composition of the mixture was estimated on this basis. A more accurate ratio of products was then determined by comparison of the areas under these peaks with those of a chromatograph to a known mixture of about the same composition. This known mixture was prepared from pure benzyldimethylamine and a mixture of essentially pure rearranged amines of types II and III, which had been obtained by distillation of the crude reaction product. This mixture of isomeric rearranged amines boiled over a range of only 1–2°. Each analysis was repeated and found to be reproducible to within 2%. In three cases, duplicate reactions were run, indicating a reproducibility of 2–3%.

From the above results and from the weights of the crude amine product, the yields of benzyldimethylamine and the mixture of rearranged amines were calculated (see Table I). The total yields of these two types of products were 90–93%, and no other product was detected.

The ratios of type II to type III rearranged

[1] Supported by the U. S. Army Research Office (Durham).

[2] C. R. Hauser and A. J. Weinheimer, *J. Am. Chem. Soc.*, **76**, 1264 (1954).

[3] In the earlier experiment with Ib, in which 1.5 equivalents of the reagent were employed, the relative extents of the two types of reaction were determined by fractional distillation of the product. See ref. 2.

Table I

Products of Reactions of Quaternary Ions Ia–e with Sodium Amide in Liquid Ammonia

| Quaternary Ion | Proportions of Rearranged Amine Mixtures: Benzyldimethylamine | Total Yields of Amines | Calculated Yields, % | | Estimated Ratios of Rear. Amines, Type II: Type III |
|---|---|---|---|---|---|
| | | | Mixtures of II and III | Benzyldimethylamine | |
| Ia | 82:18 | 93 | 76 | 17 | 5.3:1 |
| Ia[a] | 81:19 | 90 | 73 | 17 | |
| Ia[b] | 80:20 | 72 | 58 | 14 | |
| Ib[c] | 56:44 | 92 | 52 | 40 | 4:1 |
| Ic | 64:36 | 92 | 59 | 33 | 4:1 |
| Ic[a] | 62:38 | 92 | 57 | 35 | |
| Id | 52:48 | 87 | 45 | 42 | 5:1 |
| Ie | 88:12 | 93 | 82 | 11 | 7:1 |
| Ie[a] | 89:11 | 93 | 83 | 10 | |

[a] Repeated on half scale, direct addition procedure. [b] Inverse addition procedure. [c] See ref. 2.

Table II

Benzyldimethylalkylammonium Halides

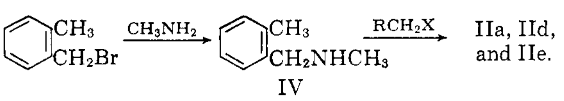
| Quaternary Ammonium Ion | Anion | Yield, % | M.P. | Empirical Formula | Calcd. | | | Found | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | C | H | N | C | H | N |
| Ia | Iodide | 95[a] | 119.5–120[b] | $C_{11}H_{18}IN$ | 45.37 | 6.23 | 4.81 | 45.67 | 6.12 | 4.92 |
| Ic | Iodide | 95 | 137.5–139 | $C_{13}H_{22}IN$ | 48.91 | 6.95 | 4.39 | 48.86 | 6.41 | 4.46 |
| Id | Bromide | 88[c] | 188–189[d] | $C_{13}H_{22}BrN$ | 57.35 | 8.15 | 5.15 | 57.62 | 8.05 | 5.18 |
| Ie | Iodide | 94 | 119–121 | $C_{12}H_{20}IN$ | 47.22 | 6.61 | 4.59 | 47.24 | 6.66 | 4.62 |

[a] Yield based on salt melting at 119–119.5°. [b] Analytical sample recrystallized twice from acetone. [c] Yield based on salt melting as 178.5–180.5°. [d] Analytical sample recrystallized from acetonitrile.

amines were estimated by vapor phase chromatography of the crude amine product employing a selective column. The chromatograph showed a peak for benzyldimethylamine, which was disregarded, and peaks for the two isomeric amines of types II and III. The relative amounts of these isomeric amines were estimated from the areas under their peaks or from the peak heights, and are given in Table I. The rearrangement product from quaternary ion Ib, assumed earlier[2] to consist entirely of amine IIb, was found to contain also IIIb. The rearrangement product from quaternary ion Ic consisted not only of amines IIc and presumably IIIc, but also of a little (5%) of a third isomer.

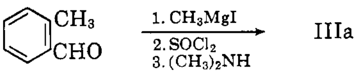
That the main chromatographic peak of the isomeric mixture was due to type II amine was ascertained for IIa, IId, and IIe by its enhancement on addition of samples of the appropriate amine, independently synthesized from secondary amine IV and the appropriate alkyl halide (Scheme B). Although some unchanged amine IV in these samples produced another peak, there was no enhancement of the minor peak, ascribed to the type III amine.

Scheme B



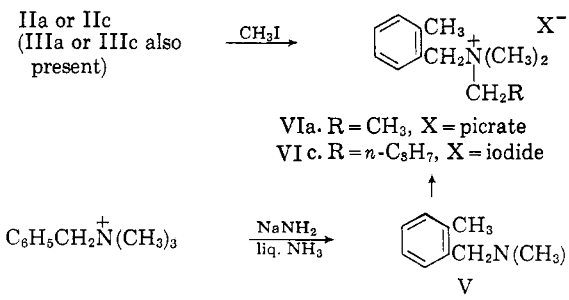
That the minor chromatographic peak from the mixture of rearranged amine was due to the type III amine was ascertained for amine IIIa by its enhancement on addition of a sample of this amine, prepared as shown in Scheme C.

Scheme C



The structures of certain of the major and minor rearrangement products were further supported by chemical means. The distilled rearrangement products from quaternary ions Ia and Ic were treated with excess methyl iodide and the resulting quaternary derivatives VIa and VIc of the major rearrangement products were isolated as suitable salts. These salts were independently synthesized from 2-methylbenzyldimethylamine[4] and the appropriate alkyl iodide (Scheme D).[5] The isomeric derivatives of minor rearrangement products IIIa and IIIc were presumably also formed, but were not isolated.

Scheme D



The minor rearrangement product IIIa was isolated in low yield from the rearrangement product

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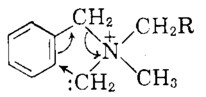
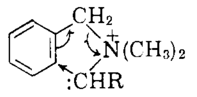
[4] S. W. Kantor and C. R. Hauser, *J. Am. Chem. Soc.*, **73**, 4122 (1951).

[5] The corresponding quaternizations of amine V with isobutyl iodide and with isopropyl bromide were unsatisfactory.

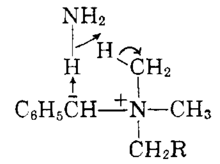
fraction of quaternary ion Ia as its picrate. This picrate was shown to be identical to that prepared from an independently synthesized sample of amine IIIa (Scheme C).

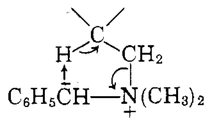
These results are of interest in connection with both the ortho-substitution rearrangement and the Hofmann elimination reaction. The fact that quaternary ammonium ions Ia–e afforded relatively more of the rearranged amines IIa–e than the isomeric amines IIIa–e is not surprising, since the intermediate methyl carbanions Ia–d′ (or that of Ie) might be expected to be more predominant than the methylene carbanions Ia–d″ (or the methinyl carbanion of Ie). Not only is the methyl hydrogen presumably more active than the methylene hydrogen, but there are two methyl groups that may form carbanions Ia–d′ and only one methylene group to give Ia–d.″


Ia–d′


Ia–d″

Actually, the benzyl carbanion, the presence of which is indicated by color, is probably the most predominant carbanion in the equilibrium mixture, but it cannot undergo the ortho-substitution rearrangement. The conversion of this carbanion to the methyl, methylene, or methinyl carbanions, which can rearrange, might occur either intermolecularly or intramolecularly. The latter event might take place directly or possibly through involvement of a molecule of ammonia as indicated, for example, in I′.


I′


I″

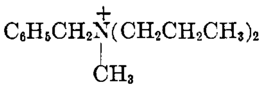
The elimination reaction appears not to involve the usual intermolecular E2 mechanism but, instead, an intramolecular $\beta$-elimination mechanism involving the benzyl (or methyl) carbanion as indicated in I″. Evidence for this mechanism is the fact that the inverse addition procedure afforded essentially the same ratio of rearrangement to elimination product as did direct addition of the salt to excess reagent.

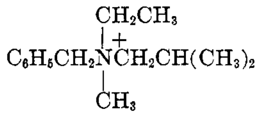
Interestingly, quaternary ion Ia, having three methyl $\beta$-hydrogens, underwent relatively less elimination than Ib–d, having only two methylene $\beta$-hydrogens. This is contrary to what might be expected on the basis of the Hofmann rule. However, this is not surprising for three reasons: first, variation of R in Ia–d may influence not only the rate of the elimination but also that of the rearrangement; second the present conditions differ considerably from those usually employed in the Hofmann elimination; third, the present rearrangement evidentally involves the intramolecular (I″) mechanism, to which the Hofmann rule may or may not apply.

Incidentally, quaternary ion Ie undergoes relatively little elimination, possibly because the planar transition state represented by I″ requires one methyl group of the isopropyl group to eclipse one of the methyl groups on nitrogen.

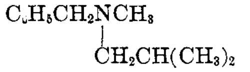
It should be mentioned that the intramolecular mechanism, designated $\alpha',\beta$-elimination, has been demonstrated by Wittig and co-workers[6–8] and by Cope and co-workers[9] to be the mechanism of elimination of certain aliphatic quaternary ammonium ions with phenyllithium. Recently, Bumgardner[10] has suggested that this mechanism operates in the elimination of the benzyldimethylhexahydrobenzylammonium ion with sodium amide in liquid ammonia, though Wittig and Burger[8] have shown that purely aliphatic quaternary ions can undergo bimolecular elimination with this reagent.

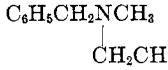
**Results with Benzylisobutylethylmethylammonium Ion (VIII).**—Like quaternary ammonium ion VII, which has been observed[2] to undergo largely the elimination reaction with sodium amide in liquid ammonia, quaternary ion VIII has now been found to exhibit largely elimination and only about 2% of rearrangement.


$$C_6H_5CH_2\underset{\underset{CH_3}{|}}{\overset{+}{N}}(CH_2CH_2CH_3)_2$$
VII


$$C_6H_5CH_2\underset{\underset{CH_3}{|}}{\overset{\overset{CH_2CH_3}{|\,+}}{N}}CH_2CH(CH_3)_2$$
VIII

Treatment of VIII with sodium amide in liquid ammonia gave amines IX and X in the ratio 65:35, as determined by vapor phase chromatography. Ethylene and isobutylene were not isolated.


$$C_6H_5CH_2\underset{\underset{CH_2CH(CH_3)_2}{|}}{N}CH_3$$
IX


$$C_6H_5CH_2\underset{\underset{CH_2CH_3}{|}}{N}CH_3$$
X

Similarly, VIII underwent mainly the elimination reaction with butyllithium in ether, though an estimated 20% of higher boiling material, presumably rearrangement product, was also obtained. The ratio of IX to X in the amine product was 61:39.

These results are comparable to those observed by Cope and co-workers,[11] who found that the related amine oxide XI afforded, on pyrolysis,

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(6) J. Rabiant and G. Wittig, *Bull. soc. chim. France*, 798 (1957).

(7) G. Wittig and R. Polster, *Ann.*, **612**, 102 (1958).

(8) G. Wittig and T. F. Burger, *ibid.*, **632**, 85 (1960).

(9) A. C. Cope, N. A. LeBel, P. T. Moore, and W. R. Moore, *J. Am. Chem. Soc.*, **83**, 3861 (1961).

(10) C. L. Bumgardner, *ibid.*, **83**, 4420 (1961).

(11) A. C. Cope, N. A. LeBel, H. -H. Lee, and W. R. Moore, *ibid.*, **79**, 4720 (1957).

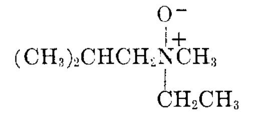
TABLE III

ELEMENTAL ANALYSES OF DISTILLED REARRANGEMENT PRODUCT MIXTURES

| Isomeric Amines in Dist. Mixture | B.P. | Mm. | Empirical Formula[a] | Calcd. C | Calcd. H | Calcd. N | Found C | Found H | Found N |
|---|---|---|---|---|---|---|---|---|---|
| IIa, IIIa | 97–97.5 | 17 | $C_{11}H_{17}N$ | 80.92 | 10.50 | 8.58 | 80.82 | 10.28 | 8.64 |
| IIc, IIIc | 110–111 | 5.9 | $C_{13}H_{21}N$ | 81.61 | 11.06 | 7.32 | 81.54 | 11.19 | 7.20 |
| IId, IIId | 105–106.5 | 6.1 | $C_{13}H_{21}N$ | 81.61 | 11.06 | 7.32 | 81.40 | 11.21 | 7.30 |
| IIe, IIIe | 99–99.5 | 6.0 | $C_{12}H_{19}N$ | 81.30 | 10.80 | 7.90 | 81.69 | 10.96 | 7.92 |

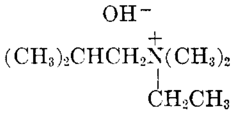
[a] Empirical formula of both rearrangement isomers.

ethylene and isopropylene in the ratio 67.6:32.4. This ratio is very close to that observed in the present reactions of ion VIII, in which the same two groups are involved. On the other hand, pyrolysis of quaternary hydroxide XII afforded ethylene and isobutylene in the ratio 99.1:0.9.[11]



$(CH_3)_2CHCH_2\underset{CH_2CH_3}{\overset{O^-}{\overset{|+}{N}}}CH_3$

XI



$(CH_3)_2CHCH_2\underset{CH_2CH_3}{\overset{+}{N}}(CH_3)_2 \quad OH^-$

XII

Since the amine oxide XI is known to undergo elimination through an intramolecular mechanism, it seems likely that ion VIII undergoes elimination by the analogous $\alpha',\beta$-mechanism such as that represented by I″. Pyrolysis of XII is known to cause elimination by an intermolecular mechanism.

## Experimental[12]

**Benzyldimethylalkylammonium Halides Ia, Ic–e (Table II).**—To an approximately 1 *N* solution of benzyldimethylamine in acetonitrile was added, with cooling, a 25–50% excess of appropriate alkyl halide. After standing overnight at room temperature, some anhydrous ether was added (avoided oiling out) and the flask was scratched. If this did not initiate crystallization, a sample of the solution was treated with excess ether, and the resulting oil was triturated with ethyl acetate to give seed crystals. These were used to initiate crystallization, which was completed by slow addition of anhydrous ether to the stirred mixture. The product was collected, redissolved in warm acetonitrile, and recrystallized by dropwise addition of three to five volumes of anhydrous ether to the stirred solution. Certain products were further recrystallized (Table II).

Benzyldimethylisobutylammonium bromide (Id) was prepared similarly, except that the reaction solution was refluxed for 48 hr. and the product was not recrystallized.

**Reactions of Quaternary Ammonium Ions Ia and Ic–e with Sodium Amide in Liquid Ammonia (Tables I and III).**—To a stirred suspension of 0.40–0.42 mole of sodium amide in 1.0 liter of liquid ammonia[13] was added, during 1.5 hr., 0.135–0.140 mole of the quaternary halide in small portions. After stirring for 1 hr. more, a small excess of ammonium chloride was added to neutralize excess sodium amide. The ammonia was evaporated with stirring as 500 ml. of ether was added. The resulting ether suspension was filtered, and the filtrate was extracted three times with 2 *N* hydrochloric acid. The combined acid extract was made basic with solid sodium hydroxide, and the resulting amine mixture was extracted three times with ether. The combined ether extract was dried over magnesium sulfate, and the ether was removed on a rotary evaporator at room temperature under about 150 mm. of pressure, leaving 18–24 g. (87–93%) of colorless, crude amine product (Table I).

The reactions were repeated in some cases on half-scale, using an identical procedure except that the salt was added over a 1-hr. period.

The reaction of quaternary salt Ia was also effected by inverse addition. To a stirred mixture (partly in solution) of 43.5 g. (0.15 mole) of Ia and 200 ml. of liquid ammonia was added, during 1 hr., a suspension of 0.15 mole of sodium amide in 300 ml. of liquid ammonia. The reaction mixture was worked up as described above to give 17.1 g. (72%) of crude amine mixture.

Vapor phase chromatography of a sample of the crude amine product using a 0.6-meter column of 20% polypropylene glycol on Chromasorb W gave a peak for benzyldimethylamine and a peak for the mixture of rearranged amines of types II and III. From the areas under these peaks, measured with a planimeter, were determined the amounts of these types of products in the crude amine mixture.

Vapor phase chromatography of a second sample using a 2.0-meter column of 20% polyethylene glycol on Chromasorb P at 125° gave peaks for benzyldimethylamine, for the type II rearranged amine, and for the type III rearranged amine. The proportions of type II to type III amines were estimated from the areas under the latter two peaks. The product from salt Id was chromatographed at 200° on this column, and the proportion of IId to IIId was estimated from the peak heights. That the major and minor peaks were due to the types II and III amines, respectively, was shown by their enhancement on addition of independently prepared samples of amines IIa, IId, IIe, and IIIa (see below) to the appropriate crude products.

Distillation of the bulk of the crude amine mixtures *in vacuo* through a 12-in. Vigreux column removed benzyldimethylamine and afforded a mid-fraction of the mixture of isomers of type II and III. These fractions, which were analyzed (Table III), were shown by vapor phase chromatography to be free of benzylidimethylamine. They were used to prepare mixtures of known proportions with pure benzyldimethylamine for the above determinations of proportions of products in the crude amine product.

Methylation of a 2.0-g. sample of the distilled mixture of amines IIa and IIIa was effected with excess methyl iodide. The reaction mixture was at first cooled and then allowed to stand overnight. The resulting oil was triturated with ethyl acetate to give crystalline, hygroscopic quaternary iodide, which was collected and dissolved in 50 ml. of a saturated solution of picric acid in 95% ethanol. The resulting precipitate was recrystallized twice from 95% ethanol to give 2-methylbenzyldimethylethylammonium picrate (VIa), m.p. 106.5–108°, identified by independent synthesis (see below).

*Anal.* Calcd. for $C_{18}H_{24}N_4O_7$: C, 53.20; H, 5.46; N, 13.97. Found: C, 53.14; H, 5.50; N, 13.78.

Methylation of a 2.0-g. sample of the distilled mixture of amines IIc and IIIc was effected similarly to give, after

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[12] Melting points and boiling points are uncorrected. Elemental analyses were performed by Galbraith Laboratories, Inc., Knoxville, Tenn., and by Dr. Ing. A. Schoeller, Kronach, West Germany. Vapor phase chromatography was performed using a Perkin-Elmer Vapor Fractometer, Model 154.

[13] C. R. Hauser, F. W. Swammer, and J. T. Adams, *Org. Reactions*, VIII, 122 (1954).

two recrystallizations from acetone, nonhygroscopic 2-methylbenzyldimethyl-*n*-propylammonium iodide (VIc), m.p. 151.5–153°, identified by independent synthesis (see below).

*Anal.* Calcd. for $C_{14}H_{24}IN$: C, 50.45; H, 7.26; N, 4.20. Found: C, 50.33; H, 7.19; N, 4.24.

Treatment of a 6.6-g. sample of the distilled mixture of amines IIa and IIIa with 100 ml. of a hot solution (saturated at room temperature) of picric acid in 95% ethanol afforded a small amount of the picrate of IIIa. This product, which crystallized after seeding the solution with an independently synthesized sample of the picrate (see below), melted at 170–171°.

*Anal.* Calcd. for $C_{17}H_{20}N_4O_7$: C, 52.07; H, 5.12; N, 14.28. Found: C, 52.65; H, 5.49; N, 14.46.

**Independent Preparations of Amines IIa, IId, and IIe (Scheme B).**—To an ice-cold solution of 40 g. (0.27 mole) of methylamine in 800 ml. of benzene was added 50 g. (0.27 mole) of α-bromo-*o*-xylene. After standing overnight at room temperature, most of the methylamine and some of the benzene were removed by distillation, and the concentrated solution was extracted three times with 2 *N* hydrochloric acid. The combined acid extract was made basic with solid sodium hydroxide, and the resulting mixture was extracted three times with ether. The combined ether extract was dried over magnesium sulfate and fractionated, giving 31.0 g. (85%) of 2-methylbenzylmethylamine (IV), b.p. 81–82° at 6.0 mm., reported b.p. 97–98° at 11 mm.[14] This product was shown to be pure by vapor phase chromatography.

A solution of 7.5 g. (0.055 mole) of amine IV and 8.6 g. (0.055 mole) of ethyl iodide in 60 ml. of benzene was allowed to stand overnight at room temperature. The reaction mixture was worked up essentially as described above for amine IV to give 7.1 g. of a mixture of two amines, presumably 2-methylbenzylethylmethylamine (IIa) and amine IV, boiling at 93–95° at 13 mm. The presence of both amines was indicated by vapor phase chromatography and the infrared spectrum.

A solution of 7.0 g. (0.052 mole) of amine IV and 7.7 g. (0.056 mole) of isobutyl bromide in 60 ml. of benzene was refluxed for 48 hr., after which crystalline material was present. The reaction mixture was worked up as described for amine IV to give a mixture of two amines, presumably 2-methylbenzyldimethylisobutylamine (IId) and amine IV, boiling at 81–102° at 6 mm. A small fraction, b.p. 95–102° at 6 mm., was shown by vapor phase chromatography to contain these two amines.

Amine IV was treated with isopropyl bromide by the procedure described above for synthesis of amine IId. On distillation, the amine product had b.p. 81–96° at 6.2 mm. The small fraction of b.p. 90–96° was shown by vapor phase chromatography to be a mixture of two amines containing a small amount of a third. The two more predominant amines in this fraction were presumed on the basis of the infrared spectrum of the fraction to be 2-methylbenzylmethylisopropylamine (IIe) and amine IV.

**Independent Synthesis of Amine IIIa (See Scheme C).**—To a stirred solution of 0.15 mole of methylmagnesium iodide in 100 ml. of ether was slowly added a solution of 9.8 g. (0.082 mole) of *o*-tolualdehyde in 50 ml. of anhydrous ether. The resulting reaction mixture was stirred for 3 hr. at room temperature. Then 50 ml. of water and 50 ml. of 2 *N* hydrochloric acid were added, and the resulting mixture was stirred for 48 hr. This mixture was filtered, and the layers were separated. The ether layer was washed with water, dried over magnesium sulfate, and diluted to 200 ml. by addition of anhydrous ether. To this stirred ether solution was added 2 drops of pyridine and, slowly, 15 ml. of thionyl chloride. This reaction was stirred for 3 hr. at room temperature. The resulting mixture was worked up and fractionated, giving 7.4 g. (59%) of 1-(2-methylphenyl)-ethyl chloride, b.p. 88–91° at 12 mm., reported b.p. 96–97° at 15 mm.[15]

A solution of 5.6 g. (0.036 mole) of the above halide and 41 g. (0.9 mole) of dimethylamine in 300 ml. of benzene was allowed to stand at room temperature for 2 days. The resulting reaction mixture was then worked up essentially as described above for amine IV, giving 2.3 g. (39%) of 2,-α-dimethylbenzyldimethylamine (IIIa), b.p. 94–95° at 17 mm.

*Anal.* Calcd. for $C_{11}H_{17}N$: C, 80.92; H, 10.50; N, 8.58. Found: C, 81.09; H, 10.66. N, 8.66.

The picrate of a sample of amine IIIa, recrystallized twice from 95% ethanol, melted at 170–171°, undepressed on admixture with the picrate of amine IIIa obtained as described above.

**Independent Synthesis of Derivatives VIa and VIc (Scheme D).**—A 2-g. sample of 2-methylbenzyldimethylamine, prepared by ortho-substitution rearrangement of benzyltrimethylammonium iodide,[4] was treated with 5 g. of ethyl iodide, and the resulting quaternary iodide was treated with picric acid essentially as described above for preparation of derivative VIa. This treatment gave quaternary picrate VIa, which, after two recrystallizations from 95% ethanol, had m.p. 106.5–108°, undepressed on admixture with derivative VIa obtained as described above.

Similarly, a sample of 2-methylbenzyldimethylamine was treated with *n*-butyl iodide. After two recrystallizations from acetone, the resulting quaternary iodide VIc had m.p. 152–153°, undepressed on admixture with derivative VIc obtained as described above.

**Benzylethylisobutylmethylammonium Iodide (VIII).**—A solution of 51.8 g. (0.45 mole) of benzylmethylamine and 85.8 g. (0.45 mole) of isobutyl iodide in 400 ml. of acetonitrile was refluxed for 48 hr. The acetonitrile was removed on a rotary evaporator, and the oil that remained was made basic with sodium hydroxide. The ether-soluble product of this treatment was extracted and was treated with excess acetic anhydride. The resulting ether solution was extracted with 2 *N* hydrochloric acid, and the acid extract was washed three times with ether. The acid layer was then made basic with solid sodium hydroxide, and the amine that separated was fractionated, giving 49.5 g. (63%) of benzylisobutylmethylamine (IX), b.p. 92–93.5° at 8.0 mm.

*Anal.* Calcd. for $C_{12}H_{19}N$: C, 81.30; H, 10.80; N, 7.90. Found: C, 81.37; H, 10.77; N, 7.96.

A solution of 8.5 g. (0.048 mole) of amine IX and 10 g. (0.075 mole) of ethyl iodide in 50 ml. of acetonitrile was refluxed for 24 hr. The reaction was worked up as described above for quaternary salts of type I, giving 13.2 g. (83%) of of quaternary salt VIII, m.p. 147–148°.

*Anal.* Calcd. for $C_{14}H_{24}IN$: C, 50.45; H, 7.26; N, 4.20. Found: C, 50.68; H, 7.16; N, 4.16.

**Reaction of Quaternary Salt VIII with Sodium Amide in Liquid Ammonia and with Butyl Lithium in Ether.**—A 6.7-g. sample (0.020 mole) of this salt was added over a period of 0.5 hr. to a stirred suspension of 0.090 mole of sodium amide in 300 ml. of liquid ammonia. The reaction mixture was worked up as described above for reaction products of salts of type I. The ether solution of the product amines was used directly for analysis.

A mixture of 2.7 g. (8 mmoles) of salt VIII and a solution of 27 mmoles of butyllithium in 20 ml. of ether was allowed to stand for 60 hr. The salt appeared to have dissolved after this time, and lithium iodide to have precipitated. The reaction mixture was poured onto ice. The layers were separated, and the ether layer was extracted with 2 *N* hydrochloric acid. Addition of sodium hydroxide to the acid layer caused separation of amine, which was extracted with ether. The resulting ether solution was used directly for analysis.

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(14) J. v. Braun and R. Michaelis, *Ann.*, **507**, 1 (1933).

(15) G. Baddeley and J. Chadwick, *J. Chem. Soc.*, 368 (1951).

The above mixtures of amines were analyzed for amines IX and X by vapor phase chromatography, using the independently synthesized amines (see above, below) to prepare mixtures of known proportions.

**Benzylethylmethylamine (X).**—This amine, b.p. 92–94.5° at 7 mm., was prepared in 62% yield from benzylmethylamine and ethyl iodide by essentially the method described above for preparation of amine IX.

*Anal.* Calcd. for $C_{10}H_{15}N$: C, 80.48; H, 10.13; N, 9.39. Found: C, 80.48: H, 10.08; N, 9.36.

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# Beckmann Rearrangement of Michler's Ketone Oxime in the Presence of Cyanide[1]

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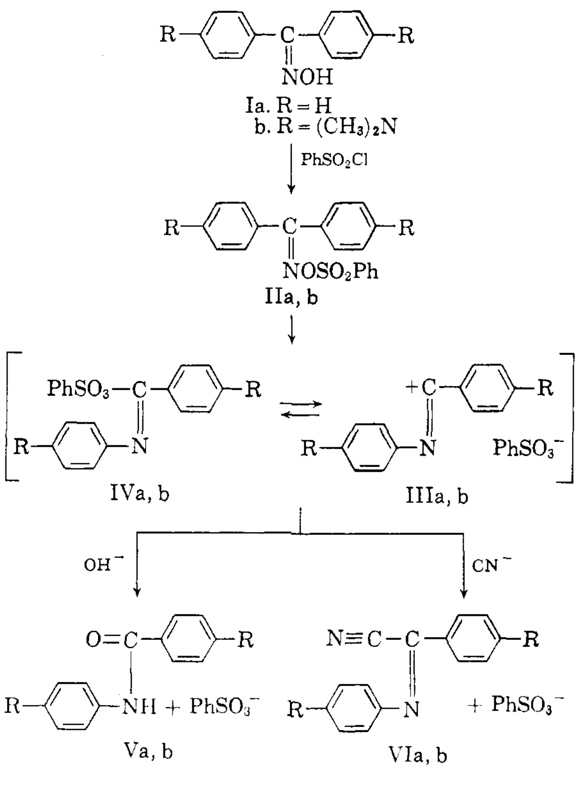
*Received December 18, 1961*

The Beckmann rearrangement of Michler's ketone oxime in the presence of cyanide ion yields α-(4-dimethylaminophenyl imino)-4-dimethylaminophenylacetonitrile. The phenyl groups are assigned *trans* positions on the basis of current theories on the mechanism of the Beckmann rearrangement.

The Beckmann rearrangement of oximes has been the subject of many investigations. One of the most significant contributions to the understanding of the reaction was made by Kuhara and co-workers.[5] They proposed that the rearrangement of benzophenone oxime by benzenesulfonyl chloride proceeds through an unstable iminosulfonate intermediate (IIIa, or IVa) which readily hydrolyzes to *N*-phenylbenzamide (Va) and benzenesulfonic acid (Chart I). Later, Oxley and Short[6] showed spectrophotometrically that the oily ester obtained from *N*-phenylbenzimino chloride and silver benzenesulfonate closely resembled Kuhara's unstable oil. They also added convincing evidence for Kuhara's iminosulfonate intermediate by forming substituted amidines through the Beckmann rearrangement of oximes in the presence of amines. In the work reported here, iminonitriles were obtained through the Beckmann transformation of benzophenone oximes in the presence of cyanide ion. The course of this Beckmann rearrangement also is best explained through Kuhara's iminosulfonate ester intermediate.

The ease with which 4,4′-bis(dimethylamino)- and 4,4′-bis(diethylamino)benzophenone oximes undergo the Beckmann rearrangement was indicated in a previous communication.[7] Subsequently, it was found that when Michler's ketone oxime, 4,4′-bis(dimethylamino)benzophenone oxime, was rearranged in the presence of potassium cyanide, a stable, red crystalline substance was formed instead of the colorless anilide. Elemental analyses of the red product established its empirical formula as $(C_9H_{10}N_2)_x$. Its infrared spectrum showed absorption in the triple bond region at 4.54 μ, suggestive of a highly stretched —C≡N group. However, the absence of absorption at 6 μ, along with the presence of a broad band underlying the 6.55 μ aromatic band, strongly indicated that if any imino function, >C = N—, were present it would have to be conjugated. Also, the spectrum established the presence of *para*-substituted aromatic

Chart I. Course of Beckmann Rearrangement



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[1] This work was supported by the U. S. Army Chemical Research and Development Laboratories under Contract No. DA18-108-CML-6016.

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[5] M. Kuhara, K. Matsumiya, and N. Matsunami, *Mem. Coll. Kyoto*, **1**, 25, 105 (1914); *cf.*, A. H. Blatt, *Chem. Revs.*, **12**, 215 (1933).

[6] P. Oxley and W. F. Short, *J. Chem. Soc.*, 1514 (1948).

[7] R. D. Morin, J. S. Warner, and R. H. Poirier, *J. Org. Chem.*, **21**, 616 (1956).