Rearrangements and Other Reactions of Benzyl-Type Quaternary Ammonium Ions with Certain Organolithium Reagents[1]

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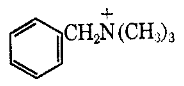
The benzyltrimethylammonium ion reacted with *n*-butyllithium in ether-hexane to form mainly the *ortho*-substitution rearrangement product, usually a considerable amount of a Stevens 1,2-shift product and smaller amounts of another Stevens product, three higher boiling amines, and a displacement product. The benzhydryltrimethylammonium ion reacted with this reagent to afford mainly a Stevens 1,2-shift product, a considerable amount of the *ortho*-rearrangement product (mostly as the benzhydryl derivative), and some tetraphenylethane. The dibenzyldimethylammonium ion reacted with this reagent to produce mainly displacement products, appreciable amounts of a Stevens 1,2-shift product, and smaller amounts of the *ortho*-rearrangement product and stilbene.

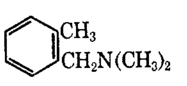
The benzyltrimethyl- and the dibenzyldimethylammonium ions have previously been shown to undergo the *ortho*-substitution rearrangements,[2] and the benzhydryltrimethylammonium ion has been shown to undergo this rearrangement and a Stevens 1,2 shift,[3] with sodium amide in liquid ammonia.

These three quaternary ions have now been found to exhibit these rearrangements and certain other types of reactions with *n*-butyllithium and other organolithium reagents.

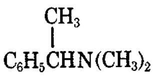
Reactions of Benzyltrimethylammonium Ion.—This quaternary ion (I) reacted with *n*-butyllithium in ether-hexane to form mainly the *ortho*-substitution rearrangement product (II), usually a considerable amount of the Stevens 1,2-shift product (III) and smaller amounts of another Stevens product (IV), and three higher boiling amines, one of which was identified as V. Also, a little (1-3%) of the neutral displacement product (VI) was obtained.



I



II

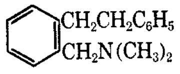


$C_6H_5CH(CH_3)N(CH_3)_2$

III

$C_6H_5CH_2CH_2N(CH_3)_2$

IV



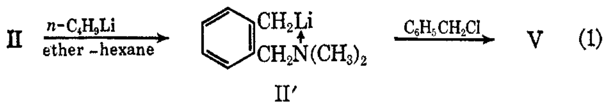
V

$C_6H_5CH_2C_4H_9\text{-}n$

VI

The three isomeric amines (II, III, and IV) were identified by comparison of their vpc retention times with those of authentic samples, which were prepared by the rearrangement of I with sodium amide in liquid ammonia,[2,4] by alkylation of dimethylamine with α-phenylethyl chloride, and by alkylation of β-phenylethylamine with formaldehyde (and formic acid),[5] respectively.

The higher boiling amine (V), which presumably arose through alkylation of II by the original quaternary ion I, was identified by comparison of its retention time with that of an authentic sample prepared by alkylation of amine II with benzyl chloride by means of *n*-butyllithium (eq 1). Incidentally, this benzylation of lithioamine II' (eq 1) appears to be the first example

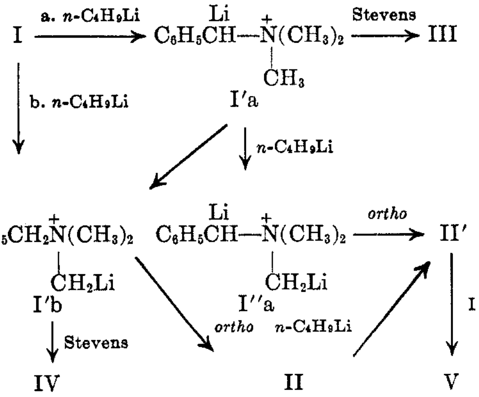


of such an alkylation but certain other types of condensations of II' have been reported.[6]

The two unidentified amines mentioned above were indicated by vpc to boil higher than the three isomeric amines but lower than V. The *n*-amylbenzene (VI) was identified by the vpc-enhancement technique.

The four amines (II-V) may be accounted for by the reactions shown in Scheme I, and the hydrocarbon (VI) by a displacement reaction at the benzyl carbon of quaternary ion I by the reagent. Scheme I shows two initial acid-base reactions of I with the reagent and the formation of several intermediates. Amine III must have arisen through a Stevens 1,2 shift of a methyl group within ylid I'a, and amine IV through a Stevens 1,2 shift of the benzyl group within intermediate ylid I'b. However, amine II (and subsequently its alkylation product V) might have been formed through an *ortho* rearrangement of either ylid I'b or the dilithio quaternary ion (I''a) which would be the secondary ionization intermediate of ylid I'a (see Scheme I). Such a secondary ionization seems entirely possible since *n*-butyllithium is potentially one of the strongest bases.

SCHEME I



Since the benzyl hydrogen of quaternary ion I should be more acidic than the methyl hydrogen, course a of Scheme I might be expected to occur preferentially. If so, the resulting benzyl ylid (I'a) would

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[1] Supported by National Science Foundation Grant No. GP-2274 and by the U. S. Army Research Office (Durham).

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

[3] K. P. Klein and C. R. Hauser, *J. Org. Chem.*, **32**, in press.

[4] W. R. Brasen and C. R. Hauser, *Org. Syn.*, **34**, 51 (1954).

[5] R. N. Icke, B. B. Wisegarver, and C. A. Alles, "Organic Syntheses," Coll. Vol. III, John Wiley and Sons, Inc., New York, N. Y., 1955, p 723.

[6] R. L. Vaulx, F. N. Jones, and C. R. Hauser, *J. Org. Chem.*, **29**, 1387 (1964).

TABLE I

AMINES FROM REACTION OF BENZYLTRIMETHYLAMMONIUM ION (I) WITH *n*-BUTYLLITHIUM IN ETHER-HEXANE

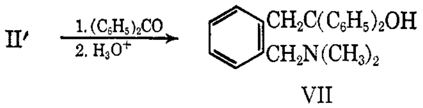
Expt	Ratio of *n*-BuLi/I	Time, hr	Temp, °C	Amine fraction, yield, %[a]	Proportion of II/III/IV	Ratio of II/III	Recovered I
1	0.5:1	24	0–5	14	...[b]	...	70
2	0.7:1	24	0–5	26	...[b]	...	65
3	0.9:1	24	0–5	58	69:25:6	2.8	37
4	1.2:1	4	0–5	18	86:11:3	7.8	75
5	1.2:1	30	0–5	58	76:22:2	3.4	36
6	1.2:1	24	25–30	69	62:36:2	1.7	..
7[c]	1.2:1	24	0–5	59	73:25:2	2.9	..
8	2.0:1	4	0–5	14	92:5:3	18	78
9	2.0:1	24	0–5	87	94:4:2	23	6
10[d]	2.0:1	24	68	92	63:35:2	1.4	1

[a] These yields, which were calculated on the basis of the molecular weight of the three isomeric amines, are only approximate since the fraction contained an estimated 10–15% of higher boiling amines. [b] Consisted mainly of II, less of III, and still less of IV. [c] Solvent was tetrahydrofuran-hexane. [d] Solvent was hexane.

have to undergo mainly, either secondary ionization to form the dilithio intermediate (I″a), or isomerization to give ylid I′b (see dotted line, Scheme I), as the predominant product was *ortho*-amine II. Although the isomerization may be slow because of the aprotic nature of the medium, it might still occur. However, since the ratio of methyl to benzyl hydrogens in I is 9:2, course b of Scheme I might possibly take place preferentially to form methyl ylid I′b, which would rearrange to give amine II. While neither of these two possible courses of reaction has been established, some evidence is presented below for the former.

It should be mentioned that the corresponding reaction of quaternary ion I with alkali amide in liquid ammonia, which affords exclusively *ortho* product II, has recently been shown to involve the intermediate formation of the benzyl ylid by isolation of its benzophenone adduct.[7] Presumably the benzyl ylid was formed directly and then isomerized to the methyl ylid which rearranged, though initial formation of the methyl ylid accompanied by vary rapid equilibration with the benzyl ylid was possible in the protic solvent used.

In Table I are summarized the approximate yields of the amine fraction (see footnote *c*), the proportions of the isomeric amines II, III, and IV obtained from quaternary ion I with *n*-butyllithium under various conditions, and the ratios of amines (II/III) which comprised most (80–90%) of the reaction products. This table shows that the *ortho*-rearrangement product (II) was formed almost exclusively (in about 75% yield) at 0–5° with a 2:1 ratio of reagent to quaternary ion I (expt 8 and 9), but that the Stevens product (III) was also produced in considerable amounts in the other experiments. The ratio of II/III was dependent on the temperature at which the reaction was effected and, especially, on the ratio of reagent to quaternary ion I. The decrease in the ratio of II/III observed as the temperature was increased from 0–5° to 25–30° (compare expt 3–5 with expt 6) is not surprising since the Stevens 1,2 shift has previously been reported to be favored over *ortho* rearrangement by elevation of temperature.[8,9] The considerable increase in the ratio II/III observed as the ratio of reagent to I was increased from approximately 1:1 to 2:1 (compare expt 3–5 with 8–9) is significant, since it furnishes support for the dilithio intermediate (I″a) in the *ortho* rearrangement (see Scheme I). Actually, lithioamine II′, which would then be formed directly, was shown to be present in the reaction mixture by treatment with benzophenone to afford adduct VII in 43–51% yield (eq 2).



VII

(2)

However, this cannot be regarded as definite evidence for dilithio intermediate I″a since, if the free amine II were formed from the rearrangement of ylid I′b, it probably would have been converted by the *n*-butyllithium to lithioamine II′, which is known to occur under similar conditions.[6]

Table I further shows that the ratio of II/III decreases from 7.8 to 3.4 with time (compare expt 4 and 5). Since amine III was found to be stable under the conditions employed, this appreciable decrease in ratio appears ascribable partly to depletion of lithioamine II′ through its alkylation to form V and, especially, because II′ effects part of the rearrangement of quaternary ion I to form II and III in a lower ratio than *n*-butyllithium (see below). Also, if dilithio derivative I″a is an intermediate, relatively more of it might be expected during the initial stages of the reaction when the concentration of *n*-butyllithium is highest, and this would lead to the formation of relatively more of II′ and, subsequently, to II. Apparently, the slight increase in the ratio of II/III with time when the ratio of reagent to I was 2:1 (expt 8 and 9, Table I) is not real, since this indicated that increase is within experimental error.

Interestingly, lithioamine II′, which was the main product from the reaction of quaternary ion I with *n*-butyllithium, was found to convert I to a similar mixture of amines. Thus, when lithioamine II′ was prepared by lithiation of amine II with *n*-butyllithium (see eq 1) and quaternary ion I then was added, there was obtained a mixture of amines II–V and the two unidentified amines (eq 3).

$$\text{I} \xrightarrow[\text{ether-hexane}]{\text{reagent II}'} \text{II–V} + \text{two unidentified amines} \qquad (3)$$

However, after taking into account the amount of lithioamine II′ employed as the reagent (eq 3), the

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[7] W. H. Puterbaugh and C. R. Hauser, *J. Am. Chem. Soc.*, **86**, 1105 (1964).

[8] G. Wittig and H. Strieb, *Ann.*, **584**, 1 (1953).

[9] C. R. Hauser, R. M. Manyik, W. R. Brasen, and P. L. Bayless, *J. Org. Chem.*, **20**, 1119 (1955).

main product produced from I was found to be Stevens amine III, not *ortho*-amine II; in fact, the ratio of amines II/III was only 0.2 or 0.3, compared to the 3.4 or 23 ratio obtained when I was treated with *n*-butyllithium under similar conditions (see Table I and the Experimental Section). This is in line with the hypothesis that the *ortho* rearrangement involves formation of dilithio intermediate I''a, since reagent II' would not be expected to effect as much secondary ionization of I'a to form I''a, as the more strongly basic *n*-butyllithium.

These results show that the reaction of quaternary ion I with *n*-butyllithium involved not only this lithio reagent, but also lithioamine II'; that is, after an initial stage, two lithio reagents, *n*-butyllithium and lithioamine II', reacted with I to form the same amines, but in different proportions.

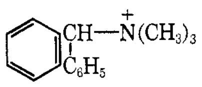
Next, quaternary ion I was treated with phenyllithium in ether to afford amines II and III and hydrocarbon VIII (eq 4).[10] The ratio of II/III was only 0.4–0.55, which again is in line with the hypothesis for the intermediate formation of dilithio intermediate I''a, since phenyllithium is a weaker base than *n*-butyllithium.

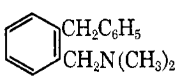
$$\mathrm{I} \xrightarrow[\text{ether}]{C_6H_5Li} \mathrm{II} + \mathrm{III} + \underset{\mathrm{VIII}}{(C_6H_5)_2CHCH_2C_6H_5} \qquad (4)$$

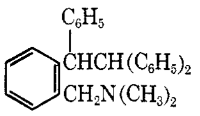
Hydrocarbon VIII appears to have arisen through a displacement reaction at the benzyl carbon of I by phenyllithium, lithiation of the resulting diphenylmethane to form benzhydryllithium which was alkylated with I. If so, the lithiation may have been facilitated by the presence of the amines produced (similar to the amine-induced lithiations reported recently[11]), since diphenylmethane has been difficult to metalate even with the more strongly basic *n*-butyllithium.[12]

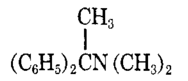
After this work was essentially complete, Lepley and Becker[13] reported that quaternary ion I reacts with *n*-butyllithium in ether–hexane at 26° to afford II and III, but they did not mention the minor products detected by us. Whereas we have found large increases in the ratio of II/III by doubling the amount of reagent at 0–5° (see Table I), they observed only a small increase (3.2 to 3.8) at 26°. Although they reported that Stevens amine III was destroyed by excess reagent in ether–hexane at 26°, we observed no appreciable destruction of III by *n*-butyllithium in 24 hr at 0–5°. They suggested a concerted mechanism for the formation of *ortho*-amine II from quaternary ion I involving simultaneous proton abstraction and attack on the aromatic ring. This process would be essentially course b of Scheme I in which the rearrangement of ylid I'b would be relatively rapid.

Reactions of Benzhydryltrimethylammonium Ion.—This quaternary ion (IX) reacted with *n*-butyllithium in ether–hexane to form a little of the *ortho*-substitution rearrangement product X, much more of its benzhydryl derivative XI, and still more of the Stevens 1,2-shift product (XII), but apparently none of the other possible Stevens product (XIII). Also, an appreciable amount of the neutral product (XIV) was obtained.


IX


X


XI


$(C_6H_5)_2\overset{CH_3}{\overset{|}{C}}N(CH_3)_2$

XII

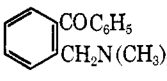
$(C_6H_5)_2CHCH_2N(CH_3)_2$

XIII

$(C_6H_5)_2CHCH(C_6H_5)_2$

XIV

The two isomeric amines (X and XII) were identified, and isomer XIII shown not to be present, by the vpc-enhancement technique. Authentic samples of these three amines were prepared by Wolff–Kishner reduction of aminoketone XV,[14] by addition of methylmagnesium iodide to imminium iodide XVI,[15] and by lithium aluminum hydride reduction of amide XVII,[16] respectively. The solid amine (XI), which presumably arose through alkylation of the lithio derivative of amine X with quaternary ion IX (see eq 1), and the neutral product XIV were isolated.


XV

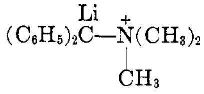
$(C_6H_5)_2C{=}\overset{+}{N}(CH_3)_2$

XVI

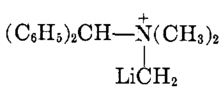
$(C_6H_5)_2CHCON(CH_3)_2$

XVII

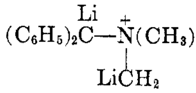
The Stevens product (XII) may be accounted for by the 1,2 shift of a methyl group within ylid IX'a, and the *ortho* product (X) by rearrangement within ylid IX'b or within dilithio intermediate IX''a.


$(C_6H_5)_2\overset{Li}{C}-\underset{CH_3}{\overset{+}{N}}(CH_3)_2$

IX'a


$(C_6H_5)_2CH-\underset{LiCH_2}{\overset{+}{N}}(CH_3)_2$

IX'b


$(C_6H_5)_2\overset{Li}{C}-\underset{LiCH_2}{\overset{+}{N}}(CH_3)_2$

IX''a

The tetraphenylethane (XIV) must have arisen through the intermediate formation of benzhydryllithium (XVIII), which underwent alkylation with quaternary ion IX; this lithio intermediate (XVIII) might have been formed by β elimination within ylid IX'b (Scheme II) or, possibly, through an exchange reaction between quaternary ion IX and *n*-butyllithium (eq 5) which would be similar to the well-known halogen–metal exchanges that occur between *n*-butyllithium and certain halides.[17]

$$(C_6H_5)_2CH\overset{+}{N}(CH_3)_3 + n\text{-}C_4H_9Li \longrightarrow (C_6H_5)_2CHLi + C_4H_9\overset{+}{N}(CH_3)_3 \qquad (5)$$

Interestingly, if the elimination mechanism operates (Scheme III) the *ortho* product (X) might also possibly arise through readdition of the benzhydryllithium (XVIII) with the imminium ion; such an elimination–readdition mechanism has recently been suggested by

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[10] See G. Wittig, R. Mangold, and G. Felletschin, *Ann.*, **560**, 116 (1948); these workers reported only III and VIII, but, at that time, vpc was presumably not available for the detection of II.

[11] See C. G. Screttas and J. F. Eastham, *J. Am. Chem. Soc.*, **87**, 3276 (1965).

[12] See R. G. Jones and H. Gilman, *Org. Reactions*, **6**, 339 (1951).

[13] A. R. Lepley and R. H. Becker, *Tetrahedron*, **21**, 2365 (1965); *J. Org. Chem.*, **30**, 3888 (1965).

[14] R. L. Vaulx and C. R. Hauser, unpublished results.

[15] C. R. Hauser and D. Lednicer, *J. Org. Chem.*, **24**, 46 (1959).

[16] T. Morikawa, *Yakugaku Zasshi*, **80**, 475 (1960); *Chem. Abstr.*, **54**, 19589*c* (1960).

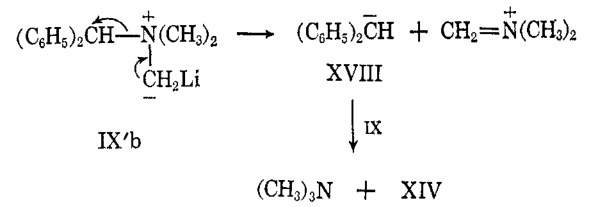
[17] Although there appears to be no precedent for the exchange indicated in eq 5, such a reaction seems possible if the mechanism were to involve a displacement on nitrogen, but presumably not if an initial coordination of the lithium were required since this cannot occur with the quaternary nitrogen. The mechanism of halogen–metal exchanges has apparently not been definitely established; see ref 11.

TABLE II

REACTION OF BENZHYDRYLTRIMETHYLAMMONIUM ION (IX) WITH n-BUTYLLITHIUM IN ETHER-HEXANE

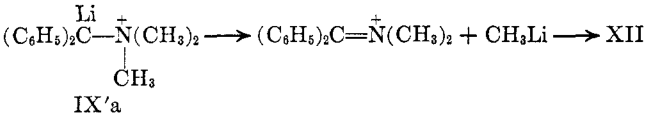
Ratio of n-BuLi/IX	Temp, °C	Yield, % X	XI	XII	XIII	XIV	Ratio of (X + XI)/XII	Recovered IX
1.2:1	0–5	1	8	10	0	5	0.9	51
2.0:1	0–5	1	19	26	0	8	0.8	17
1.2:1	25–30	1	15	18	0	8	0.9	52
2.0:1	25–30	1	21	23	0	9	0.95	36

SCHEME II



Cram[18] to be common to both the *ortho*-substitution and Stevens rearrangements. However, the Stevens 1,2 shift product that would arise from the readdition of benzhydryllithium XVIII to the imminium ion would be amine XIII, which was not detected. Another ion pair would be necessary to explain the formation of the observed amine (XII, Scheme III), and this process seems less likely as methyllithium should be a relatively poor leaving group.

SCHEME III



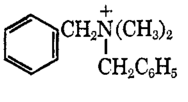
$$(C_6H_5)_2\overset{Li}{C}-\underset{CH_3}{\overset{+}{N}}(CH_3)_2 \longrightarrow (C_6H_5)_2C=\overset{+}{N}(CH_3)_2 + CH_3Li \longrightarrow XII$$

IX'a

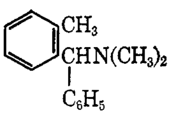
In Table II are summarized the yields of the products obtained from quaternary ion IX with n-butyllithium in ether–hexane under various conditions. This table indicates that the relative yields [or ratio of (X + XI)/XII] did not vary much with changes in temperature or ratio of reactants. However, the material balances at 0–5° were too low (71–75%) for this to be considered established.

These results with n-butyllithium are similar to those obtained previously[10] with phenyllithium in ether at 25–30° (2:1 ratio), with which quaternary ion IX afforded products XI, XII, and XIV in yields of 18, 33, and 2%, respectively.

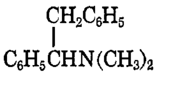
Reactions of Dibenzyldimethylammonium Ion.—This quaternary ion (XIX) reacted with n-butyllithium in ether–hexane to form some of the *ortho*-rearrangement product (XX), considerably more of the Stevens 1,2-shift product (XXI), but mainly the displacement products benzyldimethylamine (XXII) and n-amylbenzene (VI). Also, some stilbene (XXIII) was isolated.



XIX



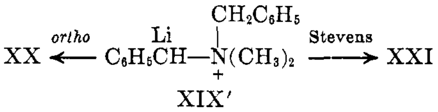
XX



XXI

Whereas the reactions of quaternary ions I and IX may involve different ylids as precursors to the *ortho*-rearrangement and main Stevens products, that of the quaternary ion XIX would require only ylid XIX' to afford both the ortho and Stevens products (Scheme IV). Nevertheless, a dilithio intermediate might still be formed in the ortho rearrangement (see below).

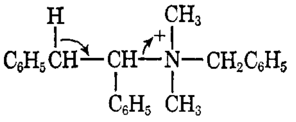
SCHEME IV



$$XX \xleftarrow{ortho} C_6H_5\overset{Li}{C}H-\underset{+}{\overset{CH_2C_6H_5}{N}}(CH_3)_2 \xrightarrow{Stevens} XXI$$

XIX'

The benzyldimethylamine and n-amylbenzene may be accounted for by an SN2 displacement involving quaternary ion XIX and n-butyllithium, and the stilbene by either β elimination of dimethylamine from Stevens product XXI[19] or alkylation of ylid XIX' with quaternary ion XIX to form XXIV which undergoes β elimination. In this last course of reaction, benzyldimethylamine would also be produced.



XXIV

In Table III are summarized the yields of the products obtained from quaternary ion XIX with n-butyllithium under various conditions. This table shows that, although the yields of the displacement products were highest and those of the Stevens product XXI greater than those of the *ortho* product (XX), relatively more XX was obtained (at 0–5°) with the larger excess of the reagent (compare expt 1 and 4); this suggests a dilithio intermediate (analogous to I''a) for the *ortho* rearrangement.

Table III further shows that the combined yields of the two rearrangement products (XX and XXI) increased and that of the displacement product VI or XXII decreased with elevation of temperature (see ratio column). Thus, the ratio of (XX + XXI)/VI increased slightly on passing from 0–5° to room temperature (compare expt 1 and 4 with 2 and 5), and greatly on passing to 68° at which temperature the yield of the Stevens product XXI was 54% (expt 3). Since elevation of temperature is known generally to favor an elimination reaction (E2) over a displacement (SN2), this result suggests an elimination–readdition mechanism[18] for the Stevens 1,2 shift; thus ylid XIX' would afford an ion pair which would recombine (eq 6). However, the original cyclic mechanism

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[18] See D. J. Cram, "Fundamentals of Carbanion Chemistry," Academic Press Inc., New York, N. Y., 1965, pp 223–238.

[19] Although a precedent for such a β elimination of an amine appears not to have been reported, a blank experiment with XXI and n-butyllithium has indicated that the small amount of stilbene produced could have arisen in this manner.

TABLE III

REACTION OF DIBENZYLDIMETHYLAMMONIUM ION (XIX) WITH *n*-BUTYLLITHIUM

Expt	Ratio of *n*-BuLi/XIX	Solvent	Temp, °C	Yield, %					Ratio of (XX + XXI)/VI
				XX	XXI	VI	XXII	XXIII	
1	1.2:1	Ether–hexane	0–5	1	20	54	51	<1	0.4
2	1.2:1	Ether	25–30	0	25	56	55	5	0.5
3	1.2:1	Hexane	68	0	54	16	14	5	3.3
4	2.0:1	Ether–hexane	0–5	5	14	56	50	<1	0.3
5	2.0:1	Ether	25–30	0	25	41	37	8	0.6

(SNi′)[2] seems supported for the *ortho* rearrangement, since this rearrangement was observed only at the lowest temperature (0–5°).

$$\mathrm{XIX'} \longrightarrow \underbrace{\mathrm{C_6H_5CH{=}\overset{+}{N}(CH_3)_2 + C_6H_5\overset{-}{C}H_2}}_{\text{ion pair}} \qquad (6)$$

These results with *n*-butyllithium are to be contrasted with those obtained previously[20] with phenyllithium in ether at 25–30° (2:1 ratio), with which quaternary ion XIX afforded the *ortho* product (XX) and the Stevens product (XXI) in yields of 36 and 52%, respectively; neither of the corresponding displacement products was reported.

Comparison of Quaternary Ions I, IX, and XIX.—The reactions of these three quaternary ions with *n*-butyllithium present some striking differences. The benzyl quaternary ion (I) underwent largely the *ortho* rearrangement, the benzhydryl quaternary ion IX slightly more of the Stevens than *ortho* rearrangement, and the dibenzyl quaternary ion XIX predominantly the displacement reaction. The relatively more Stevens 1,2 shift with IX than with I seems ascribable to greater activity of the benzhydryl hydrogen than the benzyl hydrogen, and the relatively more displacement reaction with XIX than with I or IX to an apparently better leaving capacity of benzyldimethylamine than trimethylamine. However, other factors may also be involved.

Although each of the three quaternary ions underwent mainly a different type of reaction with *n*-butyllithium, all three quaternary ions exhibited mainly a Stevens 1,2 shift with phenyllithium (see above) and predominantly the *ortho* rearrangement with potassium amide or sodium amide in liquid ammonia.[2,3]

Experimental Section[21]

Reactions of Benzyltrimethylammonium Ion I with *n*-Butyllithium.—In Table I are summarized the conditions under which these reactions were effected and most of the results obtained. The details are described below.

To a stirred mixture of 13.85 g (0.05 mole) of benzyltrimethylammonium iodide[2] in 200 ml of anhydrous ether under nitrogen at an appropriate temperature was added 16–65 ml (0.025–0.10 mole) of *n*-butyllithium (approximately 1.6 *M*) in hexane. After an appropriate time, the reaction mixture was quenched with cold water. The ether and aqueous layers were separated.

The ether layer was extracted three times with 4 *N* hydrochloric acid. The acid extracts were combined and made strongly basic with potassium hydroxide (cooled and stirred), and the resulting mixture was extracted three times with ether. The combined ether extract was dried over anhydrous magnesium sulfate, and the solvent was removed. The crude basic fraction was analyzed by vpc; six peaks were observed in the chromatograms obtained from two different columns. The amines (II–V) were identified by the enhancement technique employing authentic samples;[4,5] however, two of the higher boiling amines were not identified. The proportions of amines II, III, and IV were calculated from the peak area ratios.

The ether layer remaining from the acid extraction was dried over anhydrous magnesium sulfate and the solvent was removed to afford 0.05–0.25 g (1–3%) of neutral material which was shown to consist almost entirely of *n*-amylbenzene by vpc enhancement with an authentic sample.

The original aqueous layer was treated with ethanolic picric acid to recover any unreacted quaternary iodide I as its picrate, which, after recrystallization from 95% ethanol, had mp 166–167°, undepressed on admixture with an authentic sample.

In certain experiments amine II was isolated as its picrate which had mp 111–112° (lit.[2] 112.5–113°), undepressed upon admixture with an authentic sample.

The stability of amine III toward *n*-butyllithium was demonstrated by stirring 3.00 g (0.02 mole) of amine III and 25 ml (0.04 mole) of *n*-butyllithium in 200 ml of dry ether for 24 hr at 0–5° under nitrogen. The reaction mixture was then quenched with cold water and the layers were separated. The ether layer was dried over anhydrous magnesium sulfate and the solvent removed to afford 2.75 g (92%) of recovered III, bp 81–83° (20 mm). The vpc of the crude reaction mixture exhibited one peak identified by enhancement to be that of amine III.

Preparation of Authentic Samples of Amines II–V.—2,N,N-Trimethylbenzylamine (II)[2,4] and β-phenylethyldimethylamine (IV)[5] were prepared as previously described.

α,N,N-Trimethylbenzylamine (III) was prepared by treatment of 25 g (0.14 mole) of α-phenylethyl bromide with excess anhydrous dimethylamine in cold ether overnight. The ether solution was extracted with 4 *N* hydrochloric acid. The acid extracts were combined, made basic with potassium hydroxide (cooled and stirred), and extracted with ether. The combined ether extract was dried over anhydrous magnesium sulfate, the solvent was removed, and the residue was vacuum distilled to afford 14.50 g (70%) of III, bp 89–90° (30 mm), [lit.[13] 70.5–72° (12 mm)].

1-(2-Dimethylaminomethyl)phenyl-2-phenylethane (V) was prepared by slowly adding 0.05 mole of 2-dimethylaminomethylmethylbenzyllithium (II′)[6] in 250 ml of dry ether–hexane to a boiling solution of 7.60 g (0.06 mole) of benzyl chloride in 150 ml of dry ether. The reaction mixture was stoppered and allowed to stand at room temperature for 4 hr, then hydrolyzed by careful addition of 100 ml of water. The layers were separated. The ether layer was extracted with three 50-ml portions of 4 *N* hydrochloric acid. The combined acid extract was made basic with potassium hydroxide (cooled and stirred) and extracted with three 100-ml portions of ether. The ethereal solution was dried over anhydrous magnesium sulfate and the solvent was removed. Vacuum distillation afforded 1.15 g (15%) of amine II (identified by vpc), bp 81–84° (15 mm), and 7.95 g (66%) of product V, bp 133–135° (1.2 mm). The infrared spectrum of V had a peak at 845 cm^{-1}, characteristic of the aromatic dimethylaminomethyl group.[22] The nmr spectrum (determined in carbon tetrachloride) exhibited singlets at 128, 174, and 196 ± 1 cps, assigned to the N,N-dimethyl, benzylic, and N-benzylic protons, respectively. The aromatic multiplet was centered at 425 cps.

Anal. Calcd for $C_{17}H_{21}N$: C, 85.35; H, 8.84; N, 5.85. Found: C, 85.23; H, 8.75; N, 6.02.

Condensation of Reaction Product II′ with Benzophenone to Form VII.—To a stirred mixture of 6.95 g (0.25 mole) of benzyl-

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[20] G. Wittig, H. Tenhaeff, W. Schoch, and G. Koenig, *Ann.*, **572**, 1 (1951).

[21] The melting and boiling points are uncorrected. Elemental analyses were performed by Janssen Pharmaceutica, Beerse, Belgium. Vapor phase chromatography was carried out on F & M Model 500 and 700 gas chromatographs using 5-ft Apiezon L and 6-ft silicone gum rubber columns. Nmr spectra were obtained with a Varian A-60 spectrometer using tetramethylsilane as internal standard.

[22] See W. Q. Beard, Jr., and C. R. Hauser, *J. Org. Chem.*, **25**, 334 (1960).

trimethylammonium iodide in 300 ml of anhydrous ether at 0–5° under nitrogen was added 47 ml (0.075 mole) of *n*-butyllithium. After 24 hr a solution of 14.50 g (0.08 mole) of benzophenone in 100 ml of dry ether was added. Cold water was added after 4 hr and the reaction mixture was worked up as described above for the reaction of I with *n*-butyllithium.

From the basic fraction, there was obtained 4.40 g (51%) of 2-(dimethylaminomethyl)benzyldiphenylcarbinol (VII) which, after two recrystallizations from hexane–benzene, had mp 123–125° (lit.[23] 126–127°), undepressed upon admixture with an authentic sample.[23] Also, 1.60 g (43%) of a mixture of amines II–V, as well as the two unidentified amines, was obtained from the basic fraction.

From the original aqueous layer, 0.05 g (5%) of the picrate of quaternary ion I was isolated.

In another experiment employing 2 molecular equiv of *n*-butyllithium to quaternary ion I, there was obtained 3.70 g (43%) of VII, 1.15 g (30%) of a mixture of amines, and a 10% recovery of I as its picrate.

Reaction of Benzyltrimethylammonium Iodide I with Lithioamine II′.—To a stirred mixture of 0.025 mole of quaternary iodide I in 150 ml of dry ether at 0–5° under nitrogen was added lithioamine II′ [prepared from 4.50 g (0.03 mole) of amine II and 25 ml (0.04 mole) of *n*-butyllithium in hexane][6] in 150 ml of dry ether. After 24 hr the reaction mixture was worked up and the crude basic fraction (6.80 g) was analyzed by vpc as described above for the reaction of I with *n*-butyllithium. Amines II–V were identified by the enhancement technique; the proportions of amines II, III, and IV were indicated to be 81:17:2, respectively. After correcting for the approximate amount (10–15%) of higher boiling amines and the amount (4.50 g) of amine II employed in the preparation of lithioamine II′, the yields of II, III, and IV were calculated to be 5, 24, and 1%, respectively. Some (13%) of the starting salt I was recovered at its picrate.

In another experiment using 2 molecular equiv of reagent to quaternary ion I at 0–5° for 24 hr, amines II, III, and IV were detected in the proportion 85:14:1; the corrected yields of II, III, and IV were 10, 34, and 1%, respectively. Some (5%) quaternary ion I was recovered as its picrate.

Reaction of Benzyltrimethylammonium Iodide I with Phenyllithium.—To a stirred mixture of 0.025 mole of quaternary ion I in 150 ml of dry ether at 0–5° under nitrogen was added a suspension of 0.05 mole (110 ml of 0.46 *M* suspension) of phenyllithium.[12] After 24 hr the reaction mixture was worked up as described above for the reaction of I with *n*-butyllithium.

From the basic fraction there was obtained 0.45 g (12%) of a mixture, the vpc of which indicated amines II and III to be present in the ratio 32:68; none of amine IV was detected but traces of unidentified higher boiling amines were indicated.

The neutral fraction afforded some of 1,1,2-triphenylethane, mp 54–55° (lit.[24] 55–56°), undepressed upon admixture with an authentic sample.[24] Starting quaternary ion I was isolated as its picrate in 47% yield.

A repeat of this experiment at 25–30° for 24 hr afforded 1.35 g (36%) of an amine fraction, the vpc of which indicated the presence of amines II and III in the ratio of 28:72. The neutral fraction gave 0.05 g (14%) of 1,1,2-triphenylethane, and the original aqueous layer afforded the picrate of I in 49% yield.

Reaction of Benzhydryltrimethylammonium Iodide IX with *n*-Butyllithium.—In Table II are summarized the conditions under which these reactions were effected and most of the results obtained. The details are described below.

To a stirred mixture of 17.65 g (0.05 mole) of benzhydryltrimethylammonium iodide[2] in 300 ml of anhydrous ether under nitrogen at the specified temperature was added 38–65 ml (0.06–0.10 mole) of *n*-butyllithium in hexane. After 24 hr the reaction mixture was quenched with cold water and worked up as described for the reaction of quaternary ion I.

The basic fraction was taken up in 95% ethanol to isolate 1-[2-(dimethylaminomethyl)phenyl]-1,2,2-triphenylethane (XI), mp 175–176° (lit.[10] 177.5–179.5°). The nmr spectrum of XI (determined in deuteriochloroform) exhibited a singlet at 138 ± 1 cps, a quartet[25] centered at 193 ± 1 with a coupling constant of 13 and a chemical-shift difference between these AB protons of 43, doublets at 283 and 342 ± 1 with a coupling constant of 12, and a multiplet centered at 433 ± 1 cps attributable to the N-methyl, benzylic, methylene, and aromatic protons, respectively. The remaining basic fraction was vacuum distilled to afford amine XII contaminated with a trace (1%) of X (by vpc); none of amine XIII was detected, but some higher boiling unidentified amines were indicated.

From the neutral fraction there was isolated 1,1,2,2-tetraphenylethane (XIV) which, after recrystallization from ethyl acetate, had mp 209.5–211° (lit.[24] 214–215°), undepressed upon admixture with an authentic sample.[24]

Treatment of the aqueous layer with ethanolic picric acid afforded recovered starting quaternary ion IX as its picrate, mp 152–153°, undepressed upon admixture with an authentic sample.

Reaction of Dibenzyldimethylammonium Bromide XIX with *n*-Butyllithium.—In Table III are summarized the conditions under which these reactions were effected and most of the results obtained. The details are described below.

To a stirred mixture of 15.35 g (0.05 mole) of dibenzyldimethylammonium bromide[20] in 300 ml of anhydrous ether under nitrogen at the specified temperature (see Table III) was added 0.06–0.10 mole of *n*-butyllithium in hexane. After 24 hr the reaction mixture was quenched with cold water and worked up as described for quaternary ion I.

The basic fraction was distilled to afford benzyldimethylamine (XXII), bp 66–68° (12 mm), the methiodide of which had mp 177–178.5°, undepressed upon admixture with an authentic sample. The residue was taken up in hexane and cooled to −80° to isolate *ortho*-amine XX, mp 45–47°, the picrate of which had mp 174–175°, undepressed upon admixture with an authentic sample. Distillation of the remainder of the basic fraction afforded amine XXI, the picrate of which had mp 156–157°, undepressed upon admixture with an authentic sample.

The neutral fraction was distilled to afford *n*-amylbenzene (VI), bp 77–78 at (10 mm), which was identified by the vpc-enhancement technique employing an authentic sample. The residue was recrystallized from ethanol to give stilbene (XXIII), mp and mmp 121–122°. Some starting quaternary ion XIX was recovered as its picrate from the original aqueous layer.

Registry No.—II, 4525-48-8; III, 2449-49-2; IV, 1126-71-2; V, 7647-48-5; VII, 7647-49-6; XI, 7647-50-9; benzyldimethylamine, 103-83-3; XX, 5350-55-0; *n*-amylbenzene, 538-68-1; X, 6196-39-0; XII, 7647-53-2; XIII, 7647-54-3; XIV, 632-50-8; XXI, 6319-84-2; stilbene, 588-59-0.

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(23) W. H. Puterbaugh and C. R. Hauser, *J. Am. Chem. Soc.*, **86**, 1105 (1964).

(24) C. R. Hauser and P. J. Hamrick, Jr., *ibid.*, **79**, 3142 (1957).

(25) See J. C. Randall, J. J. McLeskey, III, P. Smith, and M. E. Hobbs, *ibid.*, **86**, 3229 (1964).