Benzyne Reaction. IX.[1] Benzyne Reaction of o-Halobenzenes with Acetonitrile or Phenylacetonitrile in Organic Solvents

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The benzyne reaction of a number of ortho-substituted halobenzenes with acetonitrile or phenylacetonitrile was carried out, in various organic solvents together with the appropriate amines in the presence of sodium amide, to give the desired meta-substituted phenylacetonitriles together with meta-substituted amino compounds. When o-chloro- and o-methylhalobenzene were used in this reaction, a mixture of the corresponding 1,3- and 1,2-disubstituted benzenes was obtained.

In previous papers, we reported the syntheses of many compounds by application of the benzyne reaction.[1,3-9] We have also reported that syntheses of a number of aminoalkyl meta-substituted phenylacetates,[10] having anticholinergic activity, *via* phenylacetic acids obtained on the hydrolysis of the corresponding phenylacetonitriles (A). Furthermore, the syntheses of various isoquinolines using phenethylamines prepared by the reduction of the corresponding phenylacetonitriles have been reported.[11] Thus, phenylacetonitriles are considerably important intermediates in the syntheses of various kinds of medicinal substance since they are convertible to phenylacetic acids and phenethylamines on hydrolysis and reduction, respectively. Among the various methods available for the preparation of meta-substituted phenylacetonitriles, benzyne reaction[1,6] of o-halobenzenes with acetonitriles has been proved to be one of the most useful methods, notably in the syntheses of m-alkoxyphenylacetonitriles, using liquid ammonia as solvent. Since liquid ammonia is not suitable as solvent from the industrial point of view, it is of interest to reinvestigate the above reaction with the use of the other solvent. In general, aliphatic amines such as piperidine, morpholine, and dimethylamine, instead of liquid ammonia, in some cases, together with ether[12-14] have been used in the benzyne reaction as solvents. In these cases they were not only used as solvent but also as nucleophiles to the benzyne. Since only liquid ammonia has hitherto been used in the case of the compounds possessing active hydrogen such as alkylnitrile, we examined the benzyne reaction with the use of various kinds of organic solvents instead of liquid ammonia in the presence of sodium amide. We now wish to report these results.

The benzyne reaction of o-chloroanisole, o-benzyloxychlorobenzene, 1,2-dichlorobenzene, and o-chlorotoluene with acetonitrile and phenylacetonitrile was examined and found to give the meta-substituted phenylacetonitriles. All the products, if they were known, were identified with authentic specimens[1,6] by comparison of the spectroscopic data. If not, their structures were determined by the microanalyses and nmr and ir spectra. In some cases, 2,2-diphenylacetonitriles (B) were also formed as described in the Experimental Section. Among the products, m-aminobenzene derivatives, which would be formed by nucleophilic reaction, were also identified by their microanalyses and nmr and ir spectra. These result are shown in Table I.

As shown in Table I, in the benzyne reaction using amines as solvent, much more aminobenzenes (C) were formed than nitriles (A), the latter yield of which was less than 25%. The possible reason for this interesting feature would be due to the fact that the amines had reacted predominantly with benzyne as nucleophiles before the anion which formed from acetonitrile or phenylacetonitrile reacted with the benzyne. When N-methylmorpholine was used as solvent in the benzyne reaction of o-chloroanisole, 3-methoxy-N-methylaniline (XI) was obtained as unusual product in good yield. It is of interest that the heating of o-chloroanisole with N-methylmorpholine in tetrahydrofuran in the presence of sodium amide also afforded XI, whose structure was proved to be correct by comparison with an authentic sample prepared by methylation of 3-methoxyaniline.

When using tetrahydrofuran as solvent, 3-methoxyaniline was also obtained as in the case of liquid ammonia. In this case, this reaction seemed to occur due to the ammonia which formed during the reaction. In these series of benzyne reactions, when the substituent R_1 at the ortho position on the benzene ring was electron-attracting group such as methoxyl or benzyloxyl group, a cyanomethyl or amino group was introduced to the meta position to afford the meta-substituted benzenes. However, with an electron-releasing group such as methyl, the reaction did not proceed with selectivity to give both compounds, ortho- and meta-substituted benzenes.[14] Among the compounds we prepared, the ratio of ortho-substituted benzene to meta isomer with V, VI, VIII, and XIV was investigated by gas chromatography, and the results are summarized in Table II.

As shown in Table II, when the substituent R_1 is methyl group, the ratio of ortho isomer to meta isomer is 1:1 and, when R_1 is chlorine group, the ratio of ortho

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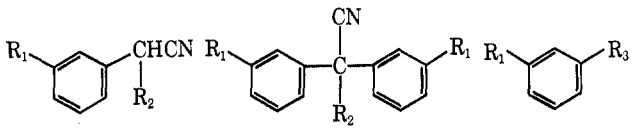
TABLE I

YIELDS OF BENZYNE REACTION PRODUCTS OF HALOBENZENES WITH NITRILES IN VARIOUS ORGANIC SOLVENTS



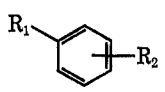
A B C

Starting material: Halobenzene	Starting material: Nitrile	Solvent (volume ratio)	Compd		Product: R_1	Product: R_2	Product: R_3	Yield, %
o-Chloroanisole	Acetonitrile	Piperidine	A	I	OCH_3	H		2.6
			C	IX	OCH_3			52.1
o-Chloroanisole	Acetonitrile	Morpholine	A	I	OCH_3	H		15.6
			C	X	OCH_3			51.1
o-Chloroanisole	Acetonitrile	Morpholine–triethylamine (1:1)	A	I	OCH_3	H		Trace
			B	XV	OCH_3	H		1.7
			C	X	OCH_3			48.5
o-Chloroanisole	Acetonitrile	Morpholine–triethylamine (2:1)	A	I	OCH_3	H		25.2
			B	XV	OCH_3	H		3.9
			C	X	OCH_3			45.5
o-Chloroanisole	Acetonitrile	*N*-Methylmorpholine	A	I	OCH_3	H		Trace
			B	XV	OCH_3	H		11.1
			C	XI	OCH_3		$NHCH_3$	40.0
o-Chloroanisole	Acetonitrile	Tetrahydrofuran	A	I	OCH_3	H		6.1
			B	XV	OCH_3	H		13.4
			C	XII	OCH_3		NH_2	9.2
o-Chloroanisole	Acetonitrile	Dioxane	A	I	OCH_3	H		Trace
			B	XV	OCH_3	H		5.5
			C	XII	OCH_3		NH_2	3.5
o-Chloroanisole	Phenylacetonitrile	Morpholine–triethylamine (2:1)	A	II	OCH_3	C_6H_5		26.7
			C	X	OCH_3			45.3
o-Chloroanisole	Phenylacetonitrile	Tetrahydrofuran	A	II	OCH_3	C_6H_5		54.8
o-Chloroanisole	Phenylacetonitrile	Dioxane	A	II	OCH_3	C_6H_5		27.4
2-Benzyloxy-1-chlorobenzene	Acetonitrile	Morpholine–triethylamine (2:1)	A	III	$OCH_2C_6H_5$	H		2.6
			C	XIII	$OCH_2C_6H_5$			40.7
2-Benzyloxy-1-chlorobenzene	Phenylacetonitrile	Tetrahydrofuran	A	IV	$OCH_2C_6H_5$	C_6H_5		58.5
1,2-Dichlorobenzene	Acetonitrile	Morpholine–triethylamine (2:1)	A	V	Cl	H		5.7[a]
1,2-Dichlorobenzene	Phenylacetonitrile	Tetrahydrofuran	A	VI	Cl	C_6H_5		20.6[a]
2-Chlorotoluene	Acetonitrile	Morpholine–triethylamine (2:1)	A	VII	CH_3	H		15.2[a]
			C	XIV	CH_3			47.1[a]
2-Chlorotoluene	Phenylacetonitrile	Tetrahydrofuran	A	VIII	CH_3	C_6H_5		48.9[a]

[a] This shows a total yield of ortho and meta isomers.

TABLE II

FORMATION RATIO OF THE ISOMERS IN THE BENZYNE REACTION OF HALOBENZENES WITH NITRILES



R_1	R_2	Compd	Solvent (volume ratio)	Yield, %	Isomer ratio ortho:meta
CH_3	CH_2CN	VII	Morpholine–triethylamine (2:1)	15.2	51.8:48.2
CH_3		XIV	Morpholine–triethylamine (2:1)	47.1	45.1:54.9
CH_3	C_6H_5CHCN	VIII	Tetrahydrofuran	48.9	23.5:76.5[a]
Cl	CH_2CN	V	Morpholine–triethylamine (2:1)	5.7	26.5:73.5
Cl	C_6H_5CHCN	VI	Tetrahydrofuran	20.6	19.1:80.9

[a] This ratio was measured by nmr spectral integration.

isomer to meta isomer becomes 1:4. Benzyne reaction with the use of morpholine–triethylamine as solvent between ortho-substituted halobenzenes and acetonitrile afforded meta-substituted phenylacetonitriles in moderate yields and, with phenylacetonitrile, tetrahydrofuran was found to be one of the best solvents.

Thus, two kinds of solvents, namely tetrahydrofuran and morpholine–triethylamine, were found to be available in the benzyne reaction of ortho-substituted halobenzenes with aliphatic nitriles.

Experimental Section[15]

3-Methoxyphenylacetonitrile (I). Benzyne Reaction of o-Chloroanisole. A.—To a stirred mixture of 30 ml of morpholine, 15.4 g of sodium amide, and 11.6 g of acetonitrile was added 10 g of *o*-chloroanisole. After the stirring had been continued for 3 hr at room temperature, the excess sodium amide was decomposed with water and extracted with ether. The extract was washed with 20% HCl to remove the basic product which was dried and evaporated. The residual oil was distilled *in vacuo* to give 1.6 g (15.6%) of I as a yellow oil, bp 116–119° (2 mm) [lit.[20] bp 124–128° (5 mm)], whose spectroscopic data were identical with those of authentic specimen. The above acidic washing was made basic with 30% NaOH and extracted with ether. The extract was washed with water, dried over Na_2SO_4, and evaporated. The remaining residue was distilled *in vacuo* to give 6.9 g (51.1%) of 3-methoxy-1-morpholinobenzene (X), bp 140–145° (0.5 mm) [lit.[21] bp 113° (0.15 mm)], whose picrate was recrystallized from ethanol–ether to give yellow prisms, mp 195–196° (lit.[21] mp 196–197°).

B.—To a stirred mixture of 100 ml of piperidine, 27.4 g of sodium amide, and 14.4 g of acetonitrile was added 25 g of *o*-chloroanisole. After the stirring had been continued for 5 hr at room temperature, the reaction mixture was worked up as above to give 0.5 g (2.6%) of 3-methoxyphenylacetonitrile and 17.1 g (52.1%) of 3-methoxy-1-piperidinobenzene (IX), bp 130–135° (0.5 mm) [lit.[21] bp 110° (0.2 mm)], whose picrate was recrystallized from ethanol–ether to afford yellow needles, mp 159–160° (lit.[21] mp 159–160°).

C.—To a stirred mixture of 30 ml of morpholine, 30 ml of triethylamine, 15.4 g of sodium amide, and 11.6 g of acetonitrile was added 10 g of *o*-chloroanisole and the stirring was continued for 4 hr at 40–45°. The reaction mixture was treated as above to give a trace of I, 0.3 g (1.7%) of bis(3-methoxyphenyl)-acetonitrile (XV), and 6.1 g (44.4%) of X.[21] All of them were identified by the comparison of their spectroscopic data with those of authentic specimens.

D.—To a stirred mixture of 40 ml of morpholine, 20 ml of triethylamine, 15.4 g of sodium amide, and 11.6 g of acetonitrile was added 10 g of *o*-chloroanisole. After the stirring had been continued for 4 hr at 30–40°, the reaction mixture was worked up as usual to give 2.6 g (25.2%) of I, 0.35 g (3.9%) of XV, and 6.3 g (45.5%) of X.[21] The compound (XV) was obtained by recrystallization of the residual substance obtained after removal of I by distillation *in vacuo*.

E.—To a stirred solution of 9.6 g of sodium amide and 5.8 g of acetonitrile in 70 ml of tetrahydrofuran was added 10 g of *o*-chloroanisole. After the stirring had been continued for 12 hr at room temperature, the reaction mixture was worked up as usual to give 0.63 g (6.1%) of I, 1.2 g (13.4%) of XV, and 0.8 g (9.2%) of 3-methoxyaniline, whose hydrochloride was identified by the mixture melting point test and comparison of the spectroscopic data with those of authentic specimen.

F.—To a stirred mixture of 70 ml of dioxane, 9.6 g of sodium amide, and 5.8 g of acetonitrile was added 10 g of *o*-chloroanisole, and the stirring was continued for 2 hr at room temperature. After refluxing for 5 hr, treatment of the reaction mixture as usual afforded a trace of I, 0.7 g (5.5%) of XV, and 0.3 g (3.5%) of XII.

G.—To a mixture of 20 ml of *N*-methylmorpholine, 8.2 g of sodium amide, and 5.8 g of acetonitrile was added 10 g of *o*-chloroanisole and the mixture was refluxed for 3 hr. After the reaction, treatment of the above mixture afforded a trace of I and 1 g (11.1%) of XV as a neutral substance. Washing with hydrochloric acid, obtained as for method A, was treated as above to give 3.2 g (40.0%) of 3-methoxy-*N*-methylaniline (XI) [bp 130–135° (3 mm); ir ν_{max}^{liquid} 3420 cm^{-1} (NH); nmr ($CDCl_3$) τ 7.26 (3 H, s, NCH_3), 6.28 (3 H, s, OCH_3), 6.37 (1 H, s, NH), 2.70–3.95 (4 H, m, aromatic protons)], whose hydrochloride was recrystallized from ethanol–ether to give colorless needles, mp 113–115°.

Anal. Calcd for $C_8H_{11}ON\cdot HCl$: C, 57.67; H, 7.39; N, 8.08. Found: C, 57.55; H, 7.45; N, 8.12.

This was identified by the comparison of the ir spectrum of the authentic specimen, which was prepared by the reduction of *N*-formyl-3-methoxyaniline with lithium aluminum hydride.

1-(3-Methoxyphenyl)-1-phenylacetonitrile (II). A.—To a mixture of 50 ml of morpholine, 25 ml of triethylamine, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 10 g of *o*-chloroanisole. After the stirring had been continued at 28–35° for 5 hr, the mixture was treated as usual to give 4.2 g (26.7%) of II, bp 162–165° (2 mm) [lit.[1] bp 152–154° (1 mm)], whose ir and nmr spectra were identical with those of authentic specimen. From the acidic washing of I by method A, 6.2 g (45.3%) of X[21] was obtained.

B.—To a stirred mixture of 60 ml of tetrahydrofuran, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 10 g of *o*-chloroanisole. The mixture was then refluxed for 4 hr and worked up as usual to afford 8.6 g (54.8%) of II.

C.—To a mixture of 60 ml of dioxane, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 10 g of *o*-chloroanisole. After the stirring had been continued under reflux for 4 hr, the mixture was worked up as usual to give 4.3 g (27.4%) of II.

3-Benzyloxyphenylacetonitrile (III).—To a stirred mixture of 40 ml of morpholine, 20 ml of triethylamine, 15.4 g of sodium amide, and 11.6 g of acetonitrile was added 15.4 g of 2-benzyloxy-1-chlorobenzene. After the stirring had been continued at 35–40° for 6 hr, the reaction mixture was treated as usual to give 0.4 g (2.6%) of III as a pale yellowish oil [bp 170–175° (1 mm) [lit.[6] bp 188–190° (3 mm)]; ir ν_{max}^{liquid} 2250 cm^{-1} (C≡N); nmr ($CDCl_3$) τ 6.45 (2 H, s, CH_2CN), 5.09 (2 H, s, OCH_2), 2.65–3.42 (9 H, m, aromatic protons)] and 7.4 g (40.7%) of 3-benzyloxy-1-morpholinobenzene (XIII) [bp 180–185° (0.7 mm); nmr ($CDCl_3$) τ 7.01 (4 H, t, CH_2NCH_2), 6.26 (4 H, t, $-CH_2OCH_2-$), 5.08 (2 H, s, $OCH_2C_6H_5$), 2.63–3.80 (9 H, m, aromatic protons)], whose hydrochloride was recrystallized from ethanol–ether to give colorless needles, mp 173–174.5°.

Anal. Calcd for $C_{17}H_{19}O_2N\cdot HCl$: C, 66.75; H, 6.60; N, 4.58. Found: C, 66.92; H, 6.90; N, 4.61.

1-(3-Benzyloxyphenyl)-1-phenylacetonitrile (IV).—To a stirred mixture of 80 ml of tetrahydrofuran, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 15.4 g of 2-benzyloxy-1-chlorobenzene. The mixture was refluxed for 4 hr and then treated as usual to give 12.4 g (58.5%) of IV as a pale yellowish oil: bp 200–205° (0.1 mm); ir ν_{max}^{liquid} 2220 cm^{-1} (C≡N); nmr ($CDCl_3$) τ 5.13 (2 H, s, OCH_2Ph), 5.13 (1 H, s, >CHCN), 2.61–3.41 (14 H, m, aromatic protons).

A Mixture of 1-(3-Chlorophenyl)-1-phenylacetonitrile and 1-(2-Chlorophenyl)-1-phenylacetonitrile (VI).—To a mixture of 60 ml of tetrahydrofuran, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 10.3 g of 1,2-dichlorobenzene. The mixture was refluxed for 4 hr and then worked up as usual to afford 3.3 g (20.6%) of VI as a yellow oil [bp 161–164° (1 mm); ir ν_{max}^{liquid} 2230 cm^{-1} (C≡N); nmr ($CDCl_3$) τ 5.05 (s, >CHCN of 3-chloro derivative), 4.47 (s, >CHCN of 2-chloro derivative), 2.63–3.07 (m, aromatic protons)], whose Beilstein test was positive.

A Mixture of 3-Chlorophenylacetonitrile and 2-Chlorophenylacetonitrile (V).—To a stirred mixture of 40 ml of morpholine, 20 ml of triethylamine, 14.1 g of sodium amide, and 11.5 g of acetonitrile was added 10.3 g of 1,2-dichlorobenzene. After the stirring had been continued at 35–40° for 4 hr, the reaction mixture was worked up as usual to afford 0.6 g (5.7%) of V as an oil [bp 95–97° (1 mm); ir ν_{max}^{liquid} cm^{-1} 2230 (C≡N); nmr ($CDCl_3$) τ 6.37 (s, CH_2CN of 3-chloro derivative), 6.27 (s, CH_2CN of 2-chloro derivative), 2.60–2.90 (m, aromatic protons)], whose Beilstein test was positive.

A Mixture of 2-Methylphenylacetonitrile and 3-Methylphenylacetonitrile (VII).—To a mixture of 50 ml of morpholine, 25 ml of triethylamine, 17.1 g of sodium amide, and 13.1 g of acetonitrile was added 10 g of 2-chlorotoluene. After the stirring

(15) Melting points and boiling points were not corrected. Gas chromatography was taken with Hitachi K-23 or JGC-750 using 10% PEG-succinate on Celite 545, 5% OV-17 on Gas Chromosorb Q, and 30% Apiezon Grease L on Celite 545 as column; ir, and nmr spectra were determined on Shimazu spectrometer, and JNM-MH-60 with tetramethylsilane as internal reference, respectively. The authentic samples of ortho- and meta-substituted phenylacetonitrile used for the comparison of the gas chromatographic data were prepared by the methods in the literatures.[16-19]

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had been continued at 35–40° for 4 hr, the reaction mixture was worked up as usual to give 1.5 g (15.2%) of VII as a colorless oil [bp 94–96° (3 mm); ir ν_{max}^{liquid} 2230 cm^{-1} (C≡N); nmr ($CDCl_3$) τ 7.83 (s, CH_3 of 2-methyl derivative), 7.80 (s, CH_3 of 3-methyl derivative), 6.60 (s, CH_2CN of the former), 6.57 (s, CH_2CN of the latter), 2.77–3.23 (m, aromatic protons)] and 6.2 g (47.1%) of XIV as a colorless oil, bp 114–116° (3 mm), both of which were separated to the following two components by the preparative gas chromatography. The first fraction afforded 2-methyl-1-morpholinobenzene [nmr ($CDCl_3$) τ 7.72 (3 H, s, CH_3), 7.18 (4, H, t, CH_2NCH_2), 6.20 (4 H, t, CH_2OCH_2), 3.71–2.65 (4 H, m, aromatic protons)], whose hydrochloride was recrystallized from ethanol–ether to give colorless needles, mp 185–186°.

Anal. Calcd for $C_{11}H_{15}ON \cdot HCl$: C, 62.08; H, 7.58; N, 6.59. Found: C, 62.12; H, 7.65; N, 6.60.

The second fraction gave 3-methyl-1-morpholinobenzene: mp 40.5–42° (from petroleum ether); nmr ($CDCl_3$) τ 7.70 (3 H, s, CH_3), 6.91 (4 H, t, CH_2NCH_2), 6.18, (4 H, t, CH_2OCH_2), 3.45–2.65 (4 H, m, aromatic protons).

Anal. Calcd for $C_{11}H_{15}ON$: C, 74.50; H, 8.52; N, 7.90. Found: C, 74.65; H, 8.61; N, 7.92.

A Mixture of 1-(2-Methylphenyl)-1-phenylacetonitrile and 1-(3-Methylphenyl)-1-phenylacetonitrile (VIII).—To a mixture of 60 ml of tetrahydrofuran, 9.6 g of sodium amide, and 16.4 g of phenylacetonitrile was added 8.9 g of 2-chlorotoluene. The reaction mixture was refluxed for 4 hr and worked up as usual to give 7 g (48.9%) of VIII as a pale yellowish oil: bp 141–143° (1 mm); ir ν_{max}^{liquid} 2230 cm^{-1} (C≡N); nmr ($CDCl_3$) τ 7.80 (s, CH_3 of 2-methyl derivative), 7.76 (s, CH_3 of 3-methyl derivative), 5.03 (s, >CHCN of 3-methyl derivative), 4.79 (s, >CHCN of 2-methyl derivative), 2.61–3.12 (m, aromatic protons).

Registry No.—IV, 26926-49-8; V, 1529-41-5; VI, 26926-51-2; VII, 2947-60-6; VIII, 26926-53-4; XI, 14318-66-2; XI hydrochloride, 26926-55-6; XIII, 26926-56-7; XIII hydrochloride, 26926-57-8; XIV, 7025-91-4; 2-methyl-1-morpholinobenzene hydrochloride, 26926-59-0; acetonitrile, 75-05-8; phenylacetonitrile, 140-29-4; *o*-chloroanisole, 766-51-8; 2-benzyloxy-1-chlorobenzene, 949-38-2; 1,2-dichlorobenzene, 95-50-1; 2-chlorotoluene, 95-49-8.

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Alkali Metal Reductions of Epoxides, Ketals, and Related Heterocycles. Intermediacy of Carbanions[1]

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Solutions of alkali metals in liquid ammonia reduce aromatic epoxides from the "most hindered" position to afford isomerically pure alcohols. Such reductions proceed *via* the most stable of two possible carbanions as demonstrated by alkylation and deuteration experiments. Aliphatic epoxides are likewise reduced to alcohols. Similar cleavages of aromatic, but not aliphatic, ketals and thioketals afford the corresponding hydrocarbons in good to excellent yield, though a deficiency of metal in such systems gives hydroxy ethers or their sulfur analogs. Monocarbanions, not *gem*-dicarbanions, have been shown to be intermediates in the reductions of ketals. Aromatic aziridines are reduced to give amines, but a reverse aldol-type condensation has been observed with one highly unsymmetrically arylated aziridine.

Although small heterocyclic ring systems such as epoxides and cyclic ketals have been reductively cleaved by a variety of reagents,[3] similar reactions effected by means of alkali metals in liquid ammonia and other inert solvents have been accomplished only in a few cases. For example, ethylene oxide,[4] indene oxide,[5] and propylene oxide[6] have been reduced by sodium in ammonia, but products were either not isolated or yields of alcohols were only fair. Certain steroidal epoxides have been cleaved by the more potent lithium–ethylamine system, but reduction of olefinic double bonds was also realized.[7,8] In similar, but unrelated studies, benzophenone diethylketal has been reported to afford a variety of products upon treatment with sodium or potassium in liquid ammonia.[9] Certain other ketals have been likewise cleaved in ammonia,[10,11] but alcohol coreagents were often present which led to concomitant reduction of aromatic rings; in addition, the yields in these reactions were only fair or not reported. Two related classes of compounds, aziridines and thioketals, appear not to have been reduced by alkali metals in ammonia. However, two bisthioketals were cleaved by lithium–ethylamine, but reduction of olefins occurred in one case,[12] and no yield was reported in the other.[13]

It has been suggested that dissolving metal reductions of epoxides and ketals proceed *via* carbanionic intermediates, but this has not been experimentally demonstrated. Indeed, one report[9] surprisingly postulates that *gem*-dialkali derivatives of diphenylmethane are intermediates in the reduction of benzophenone diethylketal in liquid ammonia.

Thus, it was the intent of the present research to not only determine the best conditions, and the scope and limitations of such reductions, but also to prove the intermediacy of carbanions. The latter was to be accom-

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