1100, 1040 cm⁻¹. Anal. Calcd for $C_{10}H_{19}O_2N_3$: C, 56.32; H, 8.89; N, 19.70. Found: C, 56.23; H, 8.93; N, 19.84.

 $(2R^*, 3R^*)$ -3-Azidodecane-1,2-diol (8a): bp 149 °C (bath temperature)/0.5 Torr; ¹H NMR (CDCl₃) δ 0.90 (br t, 3 H, CH₃), 1.10–1.85 (br, 12 H, (CH₂)₆), 2.10–3.00 (br, 2 H, OH), 3.20–3.55 (br, 1 H, CHN₃), 3.55–4.15 (br, 3 H, CH₂OH, CHOH); IR (CCl₄) 3400 (br), 2930, 2860, 2120, 1470, 1270, 1070 cm⁻¹. Anal. Calcd for C₁₀H₂₁O₂N₃: C, 55.79; H, 9.83; N, 19.52. Found: C, 55.79; H, 9.73; N, 19.64.

(2*R**,3*R**)-3-Azidodecane-1,2-diol diacetate (8a'): bp 150 °C (bath temperature)/0.3 Torr; ¹H NMR (CDCl₃) δ 0.89 (t, *J* = 6.0, Hz, 3 H, CH₃), 1.10–1.70 (br, 12 H, (CH₂)₆), 2.06 (s, 3 H, Ac), 2.11 (s, 3 H, Ac), 3.35–3.80 (br, 1 H, CHN₃), 4.13 (dd, *J* = 11.8, 6.0 Hz, 1 H, C(*H*)HOAc), 4.43 (dd, *J* = 11.8, 3.0 Hz, 1 H, C(*H*)HOAc), 5.10 (ddd, *J* = 6.0, 5.2, 3.0 Hz, 1 H, CHOAc); ¹H NMR (CDCl₃, decoupled at 3.55 δ) δ 0.89 (t, *J* = 6.0 Hz, 3 H, Ac), 1.10–1.70 (br, 12 H, (CH₂)₆), 2.06 (s, 3 H, Ac), 2.11 (s, 3 H, Ac), 4.13 (dd, *J* = 11.8, 6.0 Hz, 1 H, C(*H*)HOAc, 4.43 (dd, *J* = 11.8, 3.0 Hz, 1 H, CH₃), 1.10–1.70 (br, 12 H, (CH₂)₆), 2.06 (s, 3 H, Ac), 2.11 (s, 3 H, Ac), 4.13 (dd, *J* = 11.8, 6.0 Hz, 1 H, C(*H*)HOAc, 4.43 (dd, *J* = 11.8, 3.0 Hz, 1 H, C(H)HOAc), 5.10 (dd, *J* = 6.0, 3.0 Hz, 1 H, CHOAc); ¹H NMR (CDCl₃, decoupled at 5.10 δ) δ 0.89 (t, *J* = 6.0 Hz, 3 H, CH₃), 1.10–1.70 (br, 12 H, (CH₂)₆), 2.06 (s, 3 H, Ac), 2.11 (s, 3 H, Ac), 3.35–3.80 (br, 1 H, CH₃), 4.13 (d, *J* = 11.8 Hz, 1 H, C-(H)HOAc), 4.43 (d, *J* = 11.8 Hz, 1 H, C(H)HOAc); IR (CCl₄) 2900, 2850, 2120, 1730, 1470, 1370, 1240, 1040, 950 cm⁻¹.

 $(2R^{*,3}R^{*})$ -3-Azido-4-methylpentane-1,2-diol (10a): bp 115 °C (bath temperature)/0.5 Torr; ¹H NMR (CDCl₃) δ 0.89 (d, J = 6.4 Hz, 3 H, CH₃), 1.05 (d, J = 6.4 Hz, 3 H, CH₃), 1.98 (sept, J = 6.4 Hz, 1 H, CHMe₂), 2.75–3.20 (br, 2 H, OH), 3.13–3.55 (br, 1 H, CHN₃), 3.55–4.15 (br, 3 H, CH₂OH, CHOH); IR (CCl₄) 3400 (br), 2970, 2930, 2880, 2120, 1470, 1270, 1070 cm⁻¹. Anal. Calcd for C₆H₁₃O₂N₃: C, 45.27; H, 8.23; N, 26.40. Found: C, 45.57; H, 8.20; N, 26.11.

(2*R**,3*R**)-3-Azido-4-methylpentane-1,2-diol diacetate (10a'): bp 130 °C (bath temperature)/0.7 Torr; ¹H NMR (CDCl₃) δ 0.97 (d, J = 6.2 Hz, 3 H, CH₃), 1.08 (d, J = 6.0 Hz, 3 H, CH₃), 1.40–1.95 (m, 1 H, CHMe₂), 2.07 (s, 3 H, Ac), 2.10 (s, 3 H, Ac), 3.40 (t, J = 6.0 Hz, 1 H, CHM₃), 4.14 (dd, J = 12.4, 6.0 Hz, 1 H, C(H)HOAc), 4.47 (dd, J = 12.4, 3.2 Hz, 1 H, C(H)HOAc), 5.17 (ddd, J = 6.0, 6.0, 3.2 Hz, 1 H, CHOAc); ¹H NMR (CDCl₃, decoupled at 3.40 δ) δ 0.97 (d, J = 6.2 Hz, 3 H, CH₃), 1.08 (d, J = 6.0 Hz, 3 H, CH₃), 1.40–1.95 (m, 1 H, CHMe₂), 2.07 (s, 3 H, Ac), 2.10 (s, 3 H, Ac), 4.14 (dd, J = 12.4, 6.0 Hz, 1 H, C(H)HOAc), 4.47 (dd, J = 12.4, 3.2 Hz, 1 H, C(H)HOAc), 5.17 (dd, J = 6.0, 3.2 Hz, 1 H, CHOAc); ¹H NMR (CDCl₃, decoupled at 5.17 δ) δ 0.97 (d, J = 6.2 Hz, 3 H, CH₃), 1.08 (d, J = 6.0 Hz, 3 H, CH₃), 1.40–1.95 (m, 1 H, CHMe₂), 2.07 (s, 3 H, Ac), 2.10 (s, 3 H, Ac), 3.40 (d, J = 6.0 Hz, 1 H, CHN₃), 4.14 (d, J = 12.4 Hz, 1 H, C(H)HOAc), 4.47 (d, J = 12.4 Hz, 1 H, C(H)HOAc); IR (CCl₄) 2970, 2120, 1755, 1375, 1240, 1220, 1050 cm⁻¹.

 $(2R^*, 3R^*)$ -3-Azido-4-(benzyloxy)butane-1,2-diol (12a): Compound 12a was separated from 12b by preparative TLC (3:1 Et₂O/hexane): R_t 0.16; ¹H NMR (CDCl₃) δ 3.00-3.40 (br, 2 H, OH), 3.45-4.00 (br, 6 H, CHN₃, BnOCH₂, CH₂OH, CHOH), 4.57 (s, 2 H, PhCH₂), 7.33 (s, 5 H, Ph); IR (CCl₄) 3400 (br), 3075, 3040, 2940, 2875, 2120, 1460, 1270, 1100 cm⁻¹. Anal. Calcd for $C_{11}H_{15}O_{3}N_{3}$: C, 55.69; H, 6.37; N, 17.71. Found: C, 55.75; H, 6.26; N, 17.42.

 $(2R^*, 3R^*)$ -3-Azido-4-(benzyloxy)butane-1,2-diol diacetate (12a'): bp 185 °C (bath temperature)/0.5 Torr; ¹H NMR (CDCl₃) δ 2.05 (s, 3 H, Ac), 2.06 (s, 3 H, Ac), 3.57 (dd, J = 10.2, 6.8 Hz, 1 H, C(H)HOBn), 3.67 (dd, J = 10.2, 3.8 Hz, C(H)HOBn), 3.85 (ddd, J = 6.8, 6.8, 3.8 Hz, 1 H CHN₃), 4.16 (dd, J = 12.2, 6.0 Hz, 1 H, C(H)HOAc), 4.40 (dd, J = 12.2, 3.0 Hz, 1 H, C(H)HOAc), 4.57 (s, 2 H, PhCH₂O), 5.17 (ddd, J = 6.8, 6.0, 3.0 Hz, 1 H, CHOAc), 7.28–7.42 (m, 5 H, Ph); IR (CCl₄) 3040, 2870, 2110, 1755, 1460, 1370, 1240, 1220, 1105, 1050 cm⁻¹.

 $(2R^*, 3R^*)$ -2-Azido-4-(benzyloxy)butane-1,3-diol (12b): R_f 0.25 (3:1 Et₂O/hexane); ¹H NMR (CDCl₃) δ 2.35–2.75 (br, 2 H, OH), 3.35–4.10 (m, 6 H, CHN₃, BnOCH₂, CH₂OH, CHOH), 4.59 (s, 2 H, PhCH₂), 7.35 (s, 5 H, Ph); IR (CCl₄) 3425 (br), 3075, 3040, 2930, 2870, 2120, 1460, 1265, 1090 cm⁻¹.

(2*R**,3*R**)-2-Azido-4-(benzyloxy)butane-1,3-diol diacetate (12b'): bp 175 °C (bath temperature)/1 Torr; ¹H NMR (CDCl₃) δ 2.09 (s, 3 H, Ac), 2.10 (s, 3 H, Ac), 3.63 (dd, J = 10.8, 4.2 Hz, 1 H, C(H)HOBn), 3.70 (dd, J = 10.8, 4.2 Hz, 1 H, C(H)HOBn), 4.02 (ddd, J = 7.0, 7.0, 3.8 Hz, 1 H, CHN₃), 4.19 (dd, J = 11.6, 7.0 Hz, 1 H, C(H)HOAc), 4.30 (dd, J = 11.6, 3.8 Hz, 1 H, C-(H)HOAc), 4.55 (s, 2 H, PhCH₂O), 5.03 (ddd, J = 7.0, 4.2, 4.2 Hz, 1 H, CHOAc), 7.27–7.42 (m, 5 H, Ph); IR (CCl₄) 3040, 2875, 2120, 1755, 1460, 1375, 1230, 1090, 1050 cm⁻¹

Registry No. 1, 2984-50-1; **2a**, 118043-38-2; **2b**, 118043-39-3; **2c**, 1117-86-8; **3**, 86990-94-5; **4a**, 116911-20-7; **4a**', 118043-41-7; **4b**, 118043-40-6; **4b** (acetate), 118043-42-8; **4c**, 118043-43-9; **4c'**, 118043-49-5; **5**, 118043-44-0; **6a**, 118043-45-1; **6b**, 118043-46-2; **7**, 81096-86-8; **8a**, 118043-47-3; **8a'**, 118043-50-8; **8b**, 118043-48-4; **9**, 89459-99-4; 10a, 118242-98-1; 10a', 118043-51-9; 10b, 118242-99-2; 11, 98048-62-5; **12a**, 118203-36-4; **12a'**, 118138-64-0; **12b**, 118138-63-9; **12b'**, 118138-65-1; sodium azide, 26628-22-8; alumina, 1344-28-1.

Attachment of Phenyl Radicals, Generated from Halobenzenes and Solvated Electrons, to Alkenes in Ammonia Solution¹

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The four phenyl halides react with 1-alkenes and potassium metal, in an ammonia/t-BuOH solvent, to form the corresponding 1-phenylalkanes in yields up to 45%. The key bond-forming step is believed to be attachment of phenyl radical to C-1 of the alkene.

We recently reported² that the addition of alkali metals to liquid ammonia solutions of o-3-butenylhalobenzenes (1f-i) causes formation of two principal products, cyclized 3 and uncyclized 4, in proportions that depend on the identity of the halogen. Radical 2 was implicated as an intermediate, one that in part underwent intramolecular addition of the aryl radical center to the alkene double bond³ en route to cyclized product 3. The variation in 3/4ratio with halogen identity was ascribed mainly to differences in the time interval between formation of 2 and termination of its life by reaction with a solvated electron. This termination step forms the carbanion corresponding

⁽¹⁾ Acknowledgement is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for partial support of this work.

⁽²⁾ Meijs, G. F.; Bunnett, J. F.; Beckwith, A. L. J. J. Am. Chem. Soc. 1986, 108, 4899.

⁽³⁾ Beckwith, A. L. J.; Easton, C. J.; Serelis, A. K. Chem. Commun. 1980, 482.

to 2, which quickly is hydronated by the solvent to form 4.



We sought further examples of this phenomenon, for we believe it to be relevant to an understanding of the reactions of alkali metals with halobenzenes in the presence of acetone enolate ion, which give phenylacetone, 1-phenyl-2-propanol, and benzene in proportions that depend strongly on the identity of the leaving group.⁴ The variation has been attributed to differing extents to which the $S_{\rm RN}$ 1 chain propagation steps are operative between electron-effected formation and termination of the phenyl radical.

We now report a study of the intermolecular analogue of the cyclization of 2, namely, the addition to alkenes of phenyl radicals generated by the action of alkali metals on halobenzenes in liquid ammonia or ammonia/*tert*-butyl alcohol solvent. We envisaged a reaction pathway as depicted in Scheme I for addition to 2-methylpropene. We sought to determine whether the extent of phenyl attachment versus dehalogenation would vary on changing the nature of the halogen in PhX. Moreover, if addition were favorable, we considered it to have potential as a synthetic method for the monoalkylation of aromatic compounds, one in which the alkyl group would appear at the site vacated by the halogen atom.⁵

The reactions of aryl radicals with alkenes have received some prior attention. Bridger and Russell,⁶ in their study of the hydrogen atom donor reactivity of numerous compounds toward phenyl radical, investigated the behavior of 22 alkenes. They found the H-donor reactivity of allylic C-H sites to be considerable and obtained as well "a crude measure of the reactivity of olefins toward the addition of phenyl radicals". Their index of such reactivity, symbolized k_A/k_C ,⁷ was about unity for 2-butene and 2-pentene, about 2.5 for terminal alkenes, 5.2 for 2-methyl-1butene, and nil for cyclohexene.⁸ Scaiano and Stewart⁹ reported the overall rate constant for the reaction of phenyl radical with cyclohexene to be 2.8 × 10⁸ M⁻¹ s⁻¹.¹⁰

(8) In our laboratory, D. Palleros recently repeated the Bridger and Russell⁶ experiment in which there is competition between cyclohexene and CCl₄. He confirmed their relative reactivity determination and observed a very small amount of a product whose MS suggests it to be 1-phenyl-2-chlorocyclohexane, which would result from phenyl attachment to carbon and ensuing chlorine atom capture.

(11) Burkey, T. J.; Griller, D.; Lunazzi, L.; Nazran, A. S. J. Org. Chem. 1983, 48, 3704.



Probable Reaction Mechanism

Table I. Reactions of Halobenzenes, 2-Methylpropene, and Potassium in Ammonia or Ammonia/*tert*-Butyl Alcohol Solvent

		products, %		
halobenzene	solvent	benzene	8	9
PhCl	NH ₃	42	3.4	18
PhBr	NH ₃	46	8.6	18
PhI	NH ₃	35	2.3	14
PhCl	NH ₃ plus ^a	5 9	27	2.6
PhBr	NH ₃ plus ^a	56	15	2.9
PhI	NH ₃ plus ^a	60	15	5.1
\mathbf{PhF}^{b}	NH_3/t -BuOH ^c	67 ± 6	21 ± 4	0.6
$PhCl^{d}$	NH_3/t -BuOH ^c	54 ± 5	35 ± 3	4
$PhBr^{d}$	NH ₃ /t-BuOH ^c	45 ± 2	45 ± 1	11
PhI	NH ₃ /t-BuOH ^c	37 ± 6	36 ± 6	13 ± 1

^aNH₃ plus 2 mol of t-BuOH/mol of PhX. ^bAverage of two experiments. ^cNH₃ (67%)/t-BuOH (33%). ^dAverage of three experiments. ^eAverage of four experiments.

The Meerwein arylation of unsaturated compounds,¹² involving reaction of a diazonium salt with, for example, acrylonitrile in the presence of a copper salt, is sometimes thought to occur via aryl radical attack on the C==C linkage. There is however also evidence that reaction occurs within a ternary complex of diazonium ion, unsaturated compound, and copper ion.¹² An attempt to prepare (*p*-nitrobenzyl)dimethylcarbinyl chloride by Meerwein reaction of *p*-nitrobenzenediazonium chloride with 2-methylpropene was not successful.¹³

Results and Discussion

Our initial experiments, carried out with 2-methylpropene (5) in liquid ammonia, are detailed in Table I, first three entries. The yields of hydrocarbon, and in particular of attachment product 8, were disappointingly low and indicated radical attachment to be unfavorable under the reaction conditions employed. The alkene 9 also was

⁽⁴⁾ Bard, R. R.; Bunnett, J. F.; Creary, X.; Tremelling, M. J. J. Am. Chem. Soc. 1980, 102, 2852. Tremelling, M. J.; Bunnett, J. F. J. Am. Chem. Soc. 1980, 102, 7375.

 ⁽⁵⁾ Cf. also: Bunnett, J. F.; Gloor, B. F. J. Org. Chem. 1973, 38, 4156.
 (6) Bridger, R. F.; Russell, G. A. J. Am. Chem. Soc. 1963, 85, 3754.

⁽⁷⁾ $k_{\rm A}$ and $k_{\rm C}$ are rate constants respectively for attachment of phenyl radical to alkene carbon and abstraction of chlorine atom from CCl₄ present as a competing reactant.

⁽⁹⁾ Scaiano, J. C.; Stewart, L. C. J. Am. Chem. Soc. 1983, 105, 3609.
(10) The identical rate constant was quoted,¹¹ from ref 9, for reaction of phenyl radical with 1-hexene. We find no report on 1-hexene reactivity in ref 9 and surmise that the quotation was mistaken.

 ⁽¹²⁾ Rondestvedt, C. S., Jr. Org. React. (N.Y.) 1976, 24, 225.
 (13) Sridharan, S. Dissertation, University of California, Santa Cruz, 1974, p 185.

formed as a minor product; it was identified by comparison of its GLC retention time and MS pattern with those of an authentic sample.

Substantial quantities of aniline were found in all of the product mixtures. Aniline is thought to arise via reaction of the halobenzenes with amide ion, formed from the acid-base reaction of 7 or Ph:⁻ with ammonia. In an attempt to differentiate between conceivable $S_{\rm RN}$ 1 and benzyne pathways for aminodehalogenation, we repeated the procedure with *p*-bromotoluene instead of a halobenzene;¹⁴ that *p*-toluidine was formed to the exclusion of its meta isomer is in accord with the $S_{\rm RN}$ 1 pathway.

When the reaction was conducted in the presence of 2 equiv of *tert*-butyl alcohol to ensure ready hydronation of carbanions without the concomitant formation of amide ion, the yields of hydrocarbon products were improved but the product ratios were difficult to reproduce and the mass balances were low. (See the solvent "NH₃ plus" entries in Table I.) It was shown, in a large-scale experiment, that the solubility of 2-methylpropene (5) in such a reaction mixture was small. Globules of 5 were observed. Consequently a better solvent was sought.

In liquid ammonia/tert-butyl alcohol (2/1), the reaction proceeded much more satisfactorily. 2-Methylpropene was shown to be freely soluble in this solvent system. The yields of hydrocarbon product were high and relatively consistent from run to run. Table I summarizes the results of these experiments in the solvent " NH_3/t -BuOH" entries. These experiments were carried out by adding small lumps of potassium metal to a solution of the other reactants. Each experiment was repeated several times, and the results were reasonably reproducible.

The last-described experiments demonstrate that phenyl radical attachment to 5 occurs with moderate efficiency and, especially in the cases of PhBr and PhI, may have some preparative value. The product ratios depend strongly on the identity of the nucleofugal group. The yield of undesired benzene is highest from PhF and diminishes steadily as the halogen becomes larger. The best yield of adduct 8 occurs from bromobenzene; it is formed in somewhat lower yields from PhCl and PhI and in considerably lower yield from PhF. The amount of alkene 9 is modest (13%) from PhI and shrinks steadily as the halogen becomes lighter.

Plausibly the genesis of olefin 9 is radical disproportionation, either between two molecules of 6 or between 6 and a phenyl radical, in which a hydrogen atom is abstracted from a methyl group of 6. In disproportionation, abstraction of a hydrogen atom from 6 α to the benzene ring might be preferred over abstraction from a methyl group, but the 1-phenyl-2-methylpropene that would thereby be generated would be expected to be reduced to 8 under the reaction conditions. Compound 9 should resist reduction to 8 because its alkene double bond is not conjugated with the benzene ring.^{15,16}

Not all the benzene or 8 need arise by hydronation of the corresponding anion. Conceivably some benzene is formed by abstraction of an allylic hydrogen from 2methylpropene or from 6 by phenyl radical. Corresponding hydrogen atom abstractions by 6 afford 8. The byproduct of such abstraction from 5, the 2-methylallyl radical, might then colligate with the phenyl radical to form 9; there is some precedent for such behavior in the formation of dimeric products from the action of alkali metals on compounds of type 1 in ammonia/t-BuOH solvent.² Regardless of the mode of formation of 9, it must have been formed in an electron-deficient local environment. Compound 9 thus should be counted along with 8 as a product formed before electronation of the phenyl radical.

The two product ratios PhH/8 and PhH/(8 + 9) increase in the order PhI ~ PhBr < PhCl < PhF, which is qualitatively the same order as for two series of product ratios from the potassium-provoked reaction of acetone enolate ion with halobenzenes,⁴ and the same order as for the uncyclized/cyclized hydrocarbon product ratio from the action of alkali metal on compounds 1.² Such an order is consistent with differing time intervals being available for phenyl radical addition to 5 as the halogen is varied. In terms of the extremes, rather more time is available for reaction with 5 when the phenyl radical is derived from iodobenzene than from fluorobenzene. We have previously described a mechanistic model consistent with such observations;² its central feature is that reaction occurs during mixing, in a kinetically heterogeneous system.

We also investigated the reactions of bromobenzene with 1-hexene and with cyclohexene, induced by the addition of potassium metal. When an excess of 1-hexene was employed, the yield of hexylbenzene was 28%. Reaction with cyclohexene afforded mainly benzene and a small amount of cyclohexylbenzene (6%). The low yields with these alkenes are consistent with the phenyl radical addition reactivity of alkenes as reported by Bridger and Russell⁶ and quoted above.

Experimental Section

Gas-liquid chromatography (GLC) was carried out on a Hewlett-Packard Model 5840A instrument equipped with a capillary inlet system and flame-ionization detector. GC/MS spectra were obtained in a Finnigan Model 4000 automated gas chromatograph mass spectral system operating at 70 eV.

A typical experiment in the last $(NH_3/t-BuOH)$ section of Table I was carried out as follows. Ammonia (67 mL) was distilled from sodium into a stirred solution of bromobenzene (1.57 g; 10 mmol) in tert-butyl alcohol (33 mL), being condensed by a well-type condenser cooled by solid carbon dioxide. The reaction mixture was kept under a nitrogen atmosphere during this and subsequent procedures. 2-Methylpropene (2.64 g; 47 mmol) was then distilled in. Potassium metal (20 mmol), after being pared of crusts, was cut up into about 10 pieces, which were kept under a hydrocarbon and then added singly to the stirred refluxing reaction solution. Each lump was allowed to react completely before the next was added. After the addition was complete, the mixture was stirred for 2 min and then ammonium nitrate (2 g) was added in small portions. Chilled diethyl ether (100 mL) was added, the well-type condenser was detached, and the ammonia was allowed to evaporate during several hours. Water (100 mL) was added, the mixture was transferred to a separatory funnel, and the organic phase was separated. It was washed with water $(2 \times 100 \text{ mL})$ and dried over $MgSO_4$. After addition of an internal standard (m-dimethoxybenzene), the mixture was analyzed quantitatively by GLC (10 m \times 0.23 mm Carbowax 20M OV-101 WCOT fused silica column, 80 °C). Products were identified by their retention times; in all cases product identities were verified by "spiking" with authentic samples on a polar column (40 m \times 0.23 mm Carbowax 20M WCOT). Accurate molar response factors were determined for isobutylbenzene (8), but not for minor product 9

The experiments summarized in the first two sections of Table I were conducted similarly, the amount of t-BuOH being adjusted appropriately.

Registry No. 8, 538-93-2; 9, 3290-53-7; PhCl, 108-90-7; PhBr, 108-86-1; PhI, 591-50-4; PhF, 462-06-6; *p*-bromotoluene, 106-38-7; 1-hexene, 592-41-6; cyclohexene, 110-83-8; hexylbenzene, 1077-16-3; cyclohexylbenzene, 827-52-1; toluene, 108-88-3; *p*-toluidine, 106-49-0; 2-methylpropene, 115-11-7; benzene, 71-43-2.

⁽¹⁴⁾ The yield of p-toluidine in this experiment was 29%; it was accompanied by toluene (57%). The p-bromotoluene was observed not to be completely soluble in the reaction mixture.

⁽¹⁵⁾ Cf.: Rossi, R. A.; Bunnett, J. F. J. Org. Chem. 1973, 38, 2314.
(16) Smith, H. Organic Reactions in Liquid Ammonia; Interscience: New York, 1963; Vol. I, Part 2, p 226.