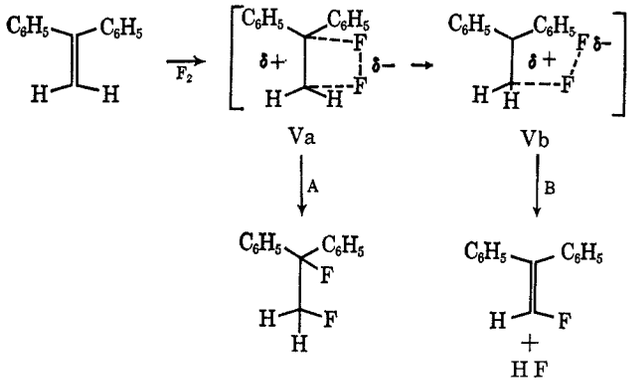
SCHEME I




The 1,1-diphenylethylene presents a favorable case for stabilization of Vb and the proton elimination route (path B) is used almost to the exclusion of path A. Path B is also favored to the extent of 3 kcal/mole by average bond energy considerations. Such eliminations are observed in chlorinations and occur to the extent of 5–15% in nonpolar solvents in the chlorination of 1-phenylpropene.[7]

Direct low-temperature addition of elemental fluorine has been shown to be an ionic process and not the expected free-radical chain mechanism. The products to be expected are those arising *via* Va and b and are not completely unlike those found with the other halogens.

### Experimental Section

**Apparatus.**—The static low-temperature fluorination apparatus has been previously described.[1] The fluorine was measured and manipulated with a standard remote fluorine system. Care must be taken to shield the reactor to protect the operator from inadvertent exotherms and/or fluorine leaks. All melting points are uncorrected.

**Materials.**—The fluorine was pure as received from Allied Chemical Corp. and was passed through an HF scrubber (NaF) before use. The 1,1-diphenylethylene was obtained from Aldrich Chemical Co. and purity established by nmr.

**Fluorination of 1,1-Diphenylethylene.**—The olefin (8.0 g, 44 mmoles) was dissolved in 400 ml of $CCl_3F$ and this solution was slurried with 2.0 g of No. 4 A Molecular Sieve®.[8] The mixture was degassed and stirred at −78°. The fluorine (44 mmoles) was carefully admitted to the reactor at a rate such that the total pressure never exceeded 5 mm. The process required about 2.5 hr. The solvents were removed to yield 9.8 g of crude colorless oil. Of this crude product, 5.7 g was placed on a silicic acid (Bio-Rad 100–200 Mesh) column (20 × 200 mm) and eluted with a pentane–methylene chloride (60:1) solvent mixture. Three components were observed in $F^{19}$ nmr and were eluted as follows.

**Peak A.**—1,1-Diphenyl-2-fluoroethylene (4.0 g 78% yield) appeared as a colorless liquid which decomposed upon distillation. The $F^{19}$ spectrum has been discussed but the vinylic proton was a doublet $J$ = 83 cps centered at $\delta$ 6.86. The remaining protons are aromatic (ratio 10:1) at $\delta$ 7.2. The infrared exhibited the following appropriate bands: 3.21 m, 6.12 m, 6.72 m, 6.98 m, 8.53 s, 9.20 s, 9.35 s, 9.75 m, 10.72 m, 11.0 m, 11.0 m, 12.01 w, 12.92 s, 13.10 s, 13.71 m, and 14.39 $\mu$ s.

*Anal.* Calcd for $C_{14}H_{11}F$: C, 84.82; H, 5.59; F, 9.58. Found: C, 84.25; H, 6.29; F, 9.40.

**Peak B.**—1,1-Diphenyl-1,2-difluoroethane (0.8 g, 14.0% yield) was eluted as a colorless solid, mp 40–41.5°, lit.[4] mp 41.8–42.6°. The proton nmr spectrum showed the two nonaromatic protons as a doublet ($J$ = 49 cps) of doublets ($J$ = 20 cps) centered at $\delta$ 4.83.

*Anal.* Calcd for $C_{14}H_{12}F_2$: C, 77.04; H, 4.54; F, 17.41. Found: C, 76.94; H, 6.27; F, 17.85.

**Peak C.**—1,1-Diphenyl-1,2,2-trifluoroethane (0.5 g, 8% yield) was eluted as a colorless oil which rapidly eliminated HF upon standing. The proton nmr spectrum showed the single nonaromatic proton as a triplet ($J_{HF}$ = 55 cps) of doublets ($J_{HF}$ = cps) centered at $\delta$ 6.13. The aromatic protons (ratio 10:1) appear as a single peak at $\delta$ 7.31. The infrared spectrum contained the following bands: 3.21 w, 3.31 w, 6.72 m, 6.94 m, 7.30 m, 8.12 w, 8.60 w, 8.78 s, 9.20 s, 9.50 m, 9.70 m, 9.88 m, 10.0 w, 10.26 w, 10.62 m, 11.0 m, 12.55 m, 13.2 s, 13.85 s, and 14.35 $\mu$ s.

*Anal.* Calcd for $C_{14}H_{11}F_3$: C, 71.18; H, 4.69; F, 24.13. Found: C, 70.68; H, 4.96; F, 24.73.

**Fluorination of 1,1-Diphenyl-2-fluoroethylene.**—The fluoroolefin (2.3 g, 14 mmoles) was fluorinated in the same manner described above with 14 mmoles of fluorine. The crude mixture (2.6 g) was immediately purified by chromatography on silicic acid to provide a single component identical (infrared, nmr) with the 1,1-diphenyl-1,2,2-trifluoroethane formed in the 1,1-diphenylethylene fluorination.

**Fluorination of *cis*-Stilbene.**—The *cis*-stilbene (4.0 g, 22 mmoles) was fluorinated at −78° in the manner already described with 22 mmoles of fluorine. The solvent was removed to yield 4.7 g (yield 95%) of a mixture (5:1) of *meso*- and *dl*-1,2-difluoro-1,2-diphenylethanes.[9] The $F^{19}$ and proton nmr spectra of both isomers were AA′XX′ cases very similar to that observed for the acenaphthylene adduct.[1]

The *meso* isomer could be separated by elution chromatography on silicic acid from the *dl* isomers as a crystalline solid, mp 99–100°.

*Anal.* Calcd for $C_{14}H_{12}F_2$: C, 77.04; H, 5.54; F, 17.41. Found: C, 76.64; H, 5.71; F, 17.62.

**Acknowledgment.**—The author is grateful to Mrs. Carolyn Haney for infrared and nmr spectra and to Mr. Morris Howard for technical assistance.

(7) R. C. Fahey, C. Schubert, *J. Am. Chem. Soc.*, **87**, 5172 (1965).

(8) ® Trademark of the Linde Co., utilized as an *in situ* HF scrubber.

(9) Further work on this system will be published shortly.

## Indirect Methods of Preparation of Pure Monoalkylphenylacetonitriles[1]

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Preparation of a pure, simple $\alpha$-alkylphenylacetonitrile by direct alkylation of phenylacetonitrile has not been very satisfactory because of accompanying dialkylation.[2,3] Thus, even though phenylacetonitrile was converted to its sodio salt by means of 1 equiv of sodium amide in liquid ammonia and 1 equiv of methyl iodide, *n*-butyl bromide, or benzyl chloride was then added, the resulting monoalkyl derivative was obtained contaminated with the dialkyl derivative and regenerated phenylacetonitrile.[2] Only 2–18% of these impurities was present when the alkylation was effected in toluene or by means of lithium amide in liquid ammonia,[2] but even these relatively small amounts are difficult to remove completely by ordinary distillation when the alkyl group introduced was *n*-butyl or lower.

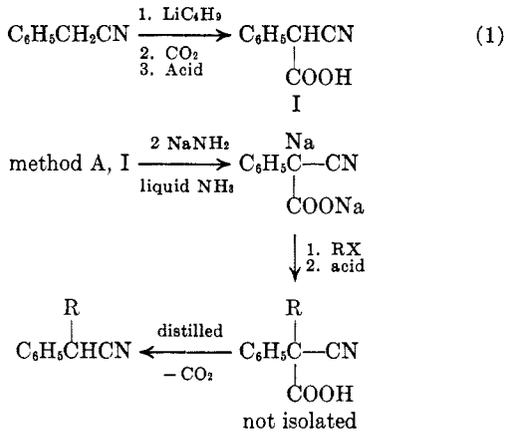
We have now devised indirect methods (A and B) that have afforded vpc-pure $\alpha$-methyl-, $\alpha$-*n*-butyl-, and $\alpha$-benzylphenylacetonitriles. Method A involved alkylation and decarboxylation starting with phenyl-

(1) Supported by the National Science Foundation.

(2) W. G. Kenyon, E. M. Haiser, and C. R. Hauser, *J. Org. Chem.*, **30**, 4135 (1965).

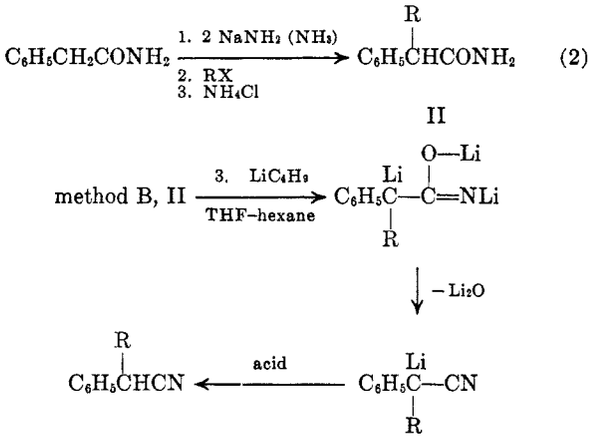
(3) A. C. Cope, H. L. Holmes, and H. O. House, *Org. Reactions*, **9**, 107 (1957).

cyanoacetic acid (I), which was prepared on a relatively large scale by carbonation of phenylacetonitrile (eq 1); the alkylation–decarboxylation involving I was performed in a single experiment as indicated below. The alkylation of the intermediate disodio salt appears to be new, but the related alkylation of disodio phenylacetate is well known.[4] The present over-all process represents introduction of the carboxyl group at the $\alpha$ position of phenylacetonitrile so that only monoalkylation can occur, and subsequent removal of this group.




(1)

Method B involved dehydrations of pure $\alpha$-alkylphenylacetamides (II), which were prepared on relatively large scales by alkylations of phenylacetamide by means of sodium amide in liquid ammonia as described previously (eq 2).[5] The dehydrations of II were effected conveniently by means of *n*-butyllithium in tetrahydrofuran–hexane, trilithioamides presumably being intermediates as indicated below; analogous dehydrations of phenyl- and diphenylacetamides were reported recently.[6] The more common procedures for dehydrations of amides by certain acidic reagents may be equally satisfactory.




(2)

In Table I are summarized the yields of the vpc-pure $\alpha$-alkylphenylacetonitriles obtained by methods A and B, and also the over-all yields (given in parentheses) realized from phenylacetonitrile (see eq 1) and phenylacetamide (see eq 2), respectively.

(4) P. J. Hamrick, Jr., and C. R. Hauser, *J. Am. Chem. Soc.*, **82**, 1957 (1960).

(5) R. B. Meyer and C. R. Hauser, *J. Org. Chem.*, **26**, 3696 (1961).

(6) E. M. Kaiser, R. L. Vaulx, and C. R. Hauser, *Tetrahedron Letters*, in press.

TABLE I

YIELDS OF $\alpha$-ALKYLPHENYLACETONITRILES BY METHODS A AND B

| Method | Alkyl halide | R of $C_6H_5CHRCN$ | Yield, % |
|---|---|---|---|
| A | $CH_3I$ | $CH_3$ | 61 (29) |
| A | $n$-$C_4H_9Br$ | $n$-$C_4H_9$ | 70 (33) |
| A | $C_6H_5CH_2Cl$ | $CH_2C_6H_5$ | 17 (8) |
| B | $CH_3I$ | $CH_3$ | 77 (17) |
| B | $n$-$C_4H_9Br$ | $n$-$C_4H_9$ | 85 (72) |
| B | $C_6H_5CH_2Cl$ | $CH_2C_6H_5$ | 76 (50) |

Table I shows that method A afforded satisfactory yields of the methyl and *n*-butyl derivatives but not of the benzyl derivative, with which much higher boiling material was obtained. Possibly the yield of the last compound could be improved by effecting the decarboxylation at lower temperature. Method B gave good yields for all three of the derivatives, but the starting compound for the $\alpha$-methyl derivative was difficult to purify; this may indicate that the monomethylation of disodiophenylacetamide (eq 2) was accompanied by appreciable dialkylation.

## Experimental Section[7]

**Phenylcyanoacetic Acid (I).**—To a solution of 11.7 g (0.1 mole) of phenylacetonitrile in 62.5 ml of anhydrous THF under nitrogen was added during 4 min, 62.5 ml (0.1 mole) of 1.6 *M* *n*-butyllithium in hexane.[8] After 20 min, the yellow solution was poured onto 2 lb of Dry Ice. Ethyl ether was added and the yellow suspension was stirred until the reaction mixture had warmed to room temperature (4 hr); addition of 200 ml of water caused all solid to dissolve. The aqueous layer was extracted with ethyl ether and the extracts were discarded. The aqueous layer was then acidified with concentrated hydrochloric acid and the resulting oil was taken up into ethyl ether. After drying (calcium sulfate) and removal of the solvent, the resulting white solid was recrystallized from ethyl ether–ligroin to afford 7.5 g (47%) of phenylcyanoacetic acid, mp 91–92° (lit.[9] mp 92°).

Preparation of this acid was also accomplished on a 0.25 *M* scale (30% yield) by reaction of sodiophenylacetonitrile with Dry Ice. The sodionitrile was prepared by means of 1 molecular equiv of sodium amide in liquid ammonia, and the ammonia was replaced by ethyl ether before carbonation.

**Alkylation–Decarboxylations Involving I (Method A).**—To a suspension of 0.1 mole of sodium amide in 300 ml of commercial anhydrous liquid ammonia[10] was added 8.05 g (0.05 mole) of solid phenylcyanoacetic acid; the solid was washed into the flask with 50 ml of ethyl ether. After 30 min, the black reaction mixture containing disodio phenylcyanoacetate (0.05 mole) was treated during 10 min with a solution of 7.1 g (0.05 mole) of methyl iodide in 50 ml of ethyl ether causing no apparent color change. After stirring for 2 hr, 15 g of solid ammonium chloride was added and the ammonia was allowed to evaporate. The residue was hydrolyzed with 100 ml of water and two ethereal extracts were discarded. The aqueous layer was acidified with concentrated hydrochloric acid and extracted with three 50-ml portions of ethyl ether.[11] After drying (magnesium sulfate) and removal of the solvent, the crude product was distilled to afford 4.0 g (61%) of vpc-pure $\alpha$-methylphenylacetonitrile, bp 90–91° (5.5 mm) [lit.[12] bp 90–93° (5.5 mm)].

Similarly, disodio phenylcyanoacetate (0.05 mole) was butylated with 6.85 g (0.05 mole) of *n*-butyl bromide. Subsequent

(7) Melting points were determined on a Mel-Temp melting point apparatus and are uncorrected. The vapor phase chromatograms were obtained on a F & M Model 500 chromatograph using a 3-ft silicone gum rubber column at 100°. All alkylphenylacetonitriles exhibited retention times which were identical with those of authentic samples.

(8) Supplied by the Foote Mineral Co., Exton, Pa.

(9) J. C. Hessler, *J. Am. Chem. Soc.*, **32**, 127 (1904).

(10) See C. R. Hauser, F. W. Swamer, and J. T. Adams, "Organic Reactions," Vol. VIII, John Wiley and Sons, Inc., New York, N. Y., 1954, p 122.

(11) The combined etheral extracts were washed with saturated aqueous sodium bisulfite before drying when methyl iodide was the alkylating agent.

(12) C. R. Hauser and W. R. Brasen, *J. Am. Chem. Soc.*, **78**, 494 (1956).

work-up afforded 6.0 g (70%) of vpc-pure α-*n*-butylphenylacetonitrile, bp 105–106° (4.5 mm) [lit.[13] bp 152–155° (20 mm)].

Also, disodio phenylcyanoacetate (0.05 mole) was benzylated with 6.33 g (0.05 mole) of benzyl chloride. Subsequent work-up and distillation afforded 1.75 g (17%) of vpc-pure α-benzylphenylacetonitrile, bp 145–146° (2 mm) [lit.[12] bp 134–135° (0.5 mm)]. The melting point (57–58°) was not depressed on admixture with an authentic sample.[12]

**α-Alkylphenylacetamides (II).**—These compounds were prepared by the method described previously[5] by employing 0.25 mole of phenylacetamide and 0.5 mole of sodium amide in 300 ml of anhydrous liquid ammonia.[10] After 30 min, the resulting brown-green suspension containing disodiophenylacetamide (0.25 mole) was treated during 10 min with a solution of 0.25 mole of the appropriate alkyl halide in 50 ml of ethyl ether. The reaction mixture was stirred for 15 min, then neutralized by the addition of 30 g of solid ammonium chloride. After the liquid ammonia had evaporated, hydrolysis and work-up were performed as before.[5] One recrystallization from ethanol afforded 41.5 g (87%) of the pure α-*n*-butyl- and 36.6 g (65%) of the pure α-benzylphenylacetamides, mp, mmp 97–98° and 132.5–133.5°, respectively. Several recrystallizations of the α-methyl derivative from aqueous ethanol and finally from benzene–hexane were required to afford 8.2 g (22%) of product, mp 95–96° (lit.[14] mp 91–92°).

**Dehydrations of II (Method B).**—To a solution of 3.725 g (0.025 mole) of α-methylphenylacetamide in 50.8 ml of anhydrous THF was added under nitrogen at room temperature during 3 min, 50.8 ml (0.0813 mole) of 1.6 *M* *n*-butyllithium in hexane.[8] The reaction was exothermic (64°), and the solution turned yellow, then orange as the second and third equivalents of the reagent were added, respectively. After refluxing for 2 hr, the reaction mixture was cooled to 0° by an ice bath and then hydrolyzed by the dropwise addition of 100 ml of 3 *N* hydrochloric acid. The layers were separated and the aqueous layer was extracted with three 50-ml portions of ethyl ether.[11] After drying (magnesium sulfate) and removal of the solvent, distillation afforded 2.5 g (77%) of pure α-methylphenylacetonitrile, bp 90–91° (5.5 mm).[12]

Similarly, 9.55 g (0.05 mole) of α-*n*-butylphenylacetamide dissolved in 101.6 ml of anhydrous THF was treated with 101.6 ml (0.1625 mole) of 1.6 *M* *n*-butyllithium in hexane[8] added during 7 min. Subsequent work-up and distillation afforded 7.35 g (85%) of vpc-pure α-*n*-butylphenylacetonitrile, bp 105–106° (4.5 mm).[13]

Also, a similar dehydration effected on a THF solution of 11.25 g (0.05 mole) of α-benzylphenylacetamide afforded 7.9 g (76%) of vpc-pure α-benzylphenylacetonitrile, bp 145–146° (2 mm).[12] The melting point (57–58°) was not depressed on admixture with an authentic sample.[12]

(13) L. H. Baldinger and J. A. Nieuwland, *ibid.*, **55**, 2851 (1933).
(14) H. Janssen, *Ann.*, **250**, 125 (1888).

## Selective Hydrogenolysis. Dehalogenation in the Presence of N-Benzyl Linkage

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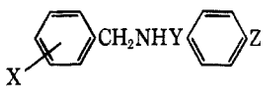
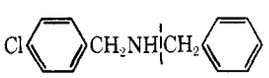
In a previous report on the attempted hydrogenolysis of N-benzyl 1-(4-chlorophenyl)-2-aminopropane (A) to obtain 1-(4-chlorophenyl)-2-aminopropane it was found that dehalogenation was the preferred reaction.[1] It seemed worthwhile to investigate the hydrogenation of some related chloro-N-benzylphenylalkylamines, where the halogen was on either ring, to learn whether dehalogenation would be a general reaction. Compounds of the following type were studied



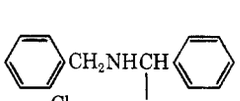
where X = 2- or 4-Cl; Y = $CH_2$, $CH(CH_3)$, or $CH_2CH_2$; Z = H or Cl. In one instance X = H, Y = $CH_2CH_2$, and Z = Cl.

Preparation of the intermediate Schiff bases was relatively simple. The amine and aldehyde were dissolved in benzene and heated under reduced pressure until the elimination of water was complete. In most instances the residue was distilled (see Table I). The resulting Schiff bases were hydrogenated in the presence of platinum on carbon. This catalyst was chosen because it had been reported that it was ineffective for dehalogenation.[2] No dehalogenation was found to have taken place. The resulting secondary amines are listed in Table II.

The amines were hydrogenated in acidic medium to eliminate the effect of the basic nitrogen on dehalogenation. Acetic acid appeared to be the best medium for the reaction because of fewer solubility difficulties. A 5–10% ratio of 5% palladium on carbon was used as catalyst. As can be seen from Table III dehalogenation was the preferred reaction. The reduction of 4-chlorodibenzylamine (IX) was of particular interest in view of the work of Baltzly and Buck who studied the effect of substitution on the strength of the N-benzyl linkage.[3] They found that when the tertiary amine, N-methyl-4-chlorodibenzylamine, as the hydrochloride salt, was subjected to hydrogenation in the presence of palladized charcoal they obtained 4-chlorobenzylmethylamine. In contrast, under the conditions used in this work hydrogenolysis of IX showed that dehalogenation to dibenzylamine (E) was certainly the major reaction. It is difficult to say whether cleavage took place in the manner described by Baltzly and that



4-chlorobenzylamine was further dehalogenated or whether the amount of benzylamine resulted from further hydrogenolysis of dibenzylamine (E). However, in order to eliminate possible effect of solvent two other experiments were carried out. In one, IX as hydrochloride salt was hydrogenated in methanol according to the method of Baltzly and Buck, in a second run the base was reduced in the same solvent. The results of chromatography, 76.5% of dibenzylamine, 15.1% of IX, 91.9% dibenzylamine, and 7.4% of IX, respectively, suggest that the debenzylation noted in acetic acid solution was a secondary reaction. In the reduction of XII and XIII, the 4-chloro analog, the



presence of α-methylbenzylamine (H) probably resulted from further debenzylation of α-methyldibenzylamine (I).

(1) M. Freifelder, Y. H. Ng, and P. F. Helgren, *J. Med. Chem.*, **7**, 381 (1964).
(2) R. Baltzly, *J. Am. Chem. Soc.*, **74**, 4586 (1952).
(3) R. Baltzly and J. S. Buck, *ibid.*, **65**, 1984 (1943).