

TABLE I  
RATIO OF THE MOLE FRACTION OF FLUORINATED MONOMER IN POLYMER TO THE MOLE FRACTION OF FLUORINATED MONOMER IN MONOMER MIXTURE

	Vinyl acetate	Vinyl chloride	Styrene	Methyl methacrylate	Acrylonitrile
Chlorotrifluoroethylene	0.73	0.71	0.42	0.29	0.10
Unsymmetrical dichlorodifluoroethylene	.82	.65	.56	.26	.14
Symmetrical dichlorodifluoroethylene	.60	.29	.22	.06	< .05
1,1,2-Trichloro-3,3,3-trifluoropropene	.54	.10	< .05	< .05	< .05
2,3-Dichloro-1,1,1,4,4,4-hexafluorobutene-2	.55	.10	< .05	< .05	< .05
Hexafluorocyclobutene	.11	< .05	< .05	< .05	< .05
1,2-Dichloro-3,3,4,4,5,5-hexafluorocyclopentene	.18	< .05	< .05	< .05	< .05

The chlorotrifluoroethylene-vinyl acetate and methyl methacrylate copolymers were completely soluble in ethyl acetate. The vinyl chloride copolymer was completely soluble in ethylene dichloride. Nearly all of the styrene copolymer was soluble in benzene, but 10% was polymeric chlorotrifluoroethylene, which was insoluble in benzene as well as in the previously mentioned solvents.

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### Preparation of Tertiary Amines by the Leuckart Reaction

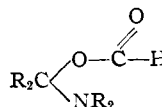
BY PETER A. S. SMITH AND A. JOHN MACDONALD

We had recently begun investigating the preparation of tertiary amines by the reaction under Leuckart conditions of ketones with secondary amine formates, when the publication by Bunnett and Marks<sup>1</sup> on the same subject appeared. Because of their considerable priority, we are abandoning further work on this subject, but wish to record our work to date insofar as it differs from their results.

We have investigated the preparation of tertiary amines from three ketones, all of which were also investigated by Bunnett and Marks. Our experimental conditions were different in that we used amine formates directly instead of first dehydrating them to formamides, and a mole ratio of amine formate to ketone of only 2:1 instead of 4:1. Furthermore, we did not use excess formic acid, or other catalyst, such as magnesium chloride. Our results are presented in the accompanying table along with those of Bunnett and Marks for comparison. The success of the reactions reported here as compared with the failure of the uncatalyzed reactions reported by Bunnett and Marks can be attributed to the greater reactivity of ammonium formates compared to formamides in the Leuckart reaction.<sup>2,3</sup>

Certain proposals regarding the mechanism of the Leuckart reaction have embodied the intermediate formation of N-alkyl imines,  $R_2C=NR$ , recently shown capable of being reduced by for-

mates.<sup>3</sup> The success of the Leuckart reaction with secondary amines, which cannot proceed by such intermediates (unless they are charged, as  $(R_2C=NR_2)^+$ ), suggests that the path through N-alkyl imine formation may not be a necessary one, although it may very well function as a concurrent reaction path in cases where such intermediates can be formed. We have been considering favorably the intermediate occurrence of formate esters of carbinol amines



which might rearrange to a tertiary amine and carbon dioxide by a 1,3-hydride shift of the type which seems probable in the Cannizzaro reaction<sup>4</sup> and which was foreshadowed by Webers and Bruce.<sup>5</sup> Such a compound might arise either by a conventional esterification of the carbinol amine, or by the addition of formic acid to the imine. These considerations can also be applied to a synthesis of tertiary amines by a Leuckart-like reaction reported in the patent literature,<sup>6</sup> which appears to have been overlooked in previous discussions. The reactions are carried out by heating mixtures of secondary amines, aldehydes or ketones, and methyl formate at 260–270°, and

TABLE I  
TERTIARY AMINES FROM KETONES AND PIPERIDINE

Ketone	Moles of reagents: pip. formate +	Amine yield, %		Bunnett and Marks' results <sup>a</sup>	
		Conv. <sup>b</sup>	Adj. <sup>c</sup>	Conv. <sup>b</sup>	Adj. <sup>c</sup>
Cyclohexanone	2	62	65	54	54
Heptanone-2	2	14	29	54	54
Heptanone-2	8 + 1 HCOOH	8	19		
Acetophenone	2	14	26	29	49

<sup>a</sup> The reagents used in each case were 2 moles N-formylpiperidine, 1 mole formic acid and 0.15 mole  $MgCl_2 \cdot 6H_2O$  per mole ketone. <sup>b</sup> Conversion; yield of amine based on ketone used. <sup>c</sup> Adjusted yield, corrected for recovered ketone.

(1) J. F. Bunnett and J. L. Marks, *THIS JOURNAL*, **71**, 1587 (1949). A comprehensive article on this subject by E. Staple and E. C. Wagner (*J. Org. Chem.*, **14**, 559 (1949)) appeared a month after this note was submitted.

(2) F. S. Crosley and M. D. Moore, *J. Org. Chem.*, **9**, 529 (1944).

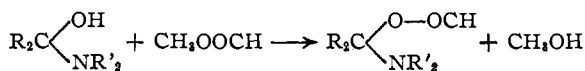
(3) E. R. Alexander and R. B. Wildman, *THIS JOURNAL*, **70**, 1187 (1948).

(4) E. R. Alexander, *ibid.*, **69**, 289 (1947); T. A. Geissman, in R. Adams, "Organic Reactions," Vol. II, John Wiley and Sons, Inc., New York, N. Y., 1946, p. 96.

(5) V. J. Webers and W. F. Bruce, *ibid.*, **70**, 1422 (1948).

(6) W. Speer, German Patent 620,510 (to I. G. Farbenind. A. G.), *C. A.*, **30**, 7328 (1936); I. G. Farbenind. A. G., French Patent 751,286, *ibid.*, **29**, 3687<sup>o</sup> (1935).

presumably involve a transesterification step to form carbinolamine formates



#### Experimental

All of the Leuckart reactions were run essentially as described below for the example of cyclohexanone.

**N-Cyclohexylpiperidine.**—Piperidine (43 g., 0.5 mole) was added to 98% formic acid (23 g., 0.5 mole) rapidly with cooling by tap water, and cyclohexanone (25 g., 0.25 mole) was added to the hot mixture which was then refluxed for five and one-half hours; the addition of a boiling chip was imperative to prevent evolution of the generated carbon dioxide in violent bumps. The cooled solution was poured into several volumes of water, acidified with 50 cc. of concd. hydrochloric acid, and extracted with three portions of benzene. Distillation of the dried extracts yielded 1.3 g. (5%) of recovered cyclohexanone.

To the aqueous solution, digested for six hours to hydrolyze N-formylpiperidine, which is otherwise difficult to fractionate from N-cyclohexylpiperidine, was added 30 g. of sodium hydroxide in concentrated aqueous solution. About 400 cc. of steam distillate was then condensed, from which the product was collected by separation of the layers and extraction of the aqueous phase with petroleum ether (b. p. 60–75°). The combined dried extracts were distilled *in vacuo*; yield 25.4 g. (61%) of N-cyclohexylpiperidine, b. p. 114–118° (25 mm.),  $n_{20}^D$  1.4862. From the hold-up in the distilling apparatus was obtained an additional quantity of amine as its hydrochloride; wt. 0.66 g. (1.3%), m. p. 291–293° (cor.).

(7) Previous b. p.'s reported for N-cyclohexylpiperidine are 106–107° (16 mm.) (C. Mannich and H. Davidsen, *Ber.*, **69**, 2106 (1936)), 122–123° (22 mm.) (ref. 6), and 98–100° (100 mm.) (French Patent 751,206, Goodyear Tire and Rubber Co., *C. A.*, **28**, 1049<sup>a</sup> (1934)). We assume the last value to be a typographical error for 98–100° (10 mm.).

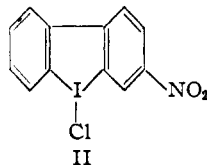
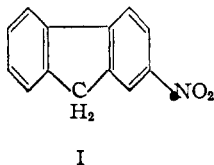
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### Preparation of 4-Nitrodiphenyleneiodonium Chloride

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Recent work<sup>2</sup> has shown that 2-nitrofluorene (I) is weakly carcinogenic. For this reason it was



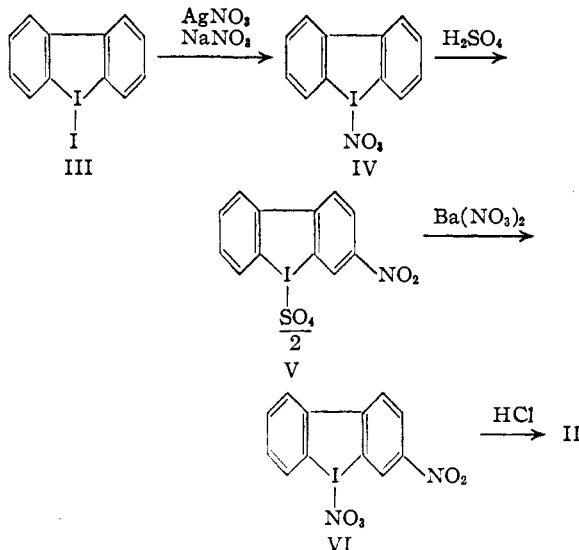
considered possible that 4-nitrodiphenyleneiodonium chloride (II) might show similar activity. Although II is a salt, there is a superficial structural resemblance between II and I. Moreover, iodonium compounds have been shown to have a certain chemotherapeutic action.<sup>3</sup> Iodonium

(1) At present graduate student in Chemistry, Harvard University, Cambridge, Mass.

(2) Morris, Dubnik, Dunn and Johnson, *Cancer Research*, **1**, 730 (1947).

(3) Freedlander and French, *Proc. Soc. Exptl. Biol. Med.*, **63**, 319 (1946); *C. A.*, **41**, 2115 (1947).

compounds have also been shown to react with thiol compounds.<sup>4</sup> In this communication is described the preparation of 4-nitrodiphenyleneiodonium chloride and some of its derivatives. The reactions are



#### Experimental<sup>5</sup>

**Diphenyleneiodonium iodide (III)** was prepared according to Mascarelli and Benati.<sup>6</sup> To a vigorously stirred suspension of III (29 g.) in 1000 ml. of boiling water was added a saturated solution of 25 g. of silver nitrate in boiling water. The reaction mixture was then treated with 200 ml. of a hot saturated solution of sodium nitrate. Stirring was continued for one-half hour and after cooling in an ice-water-bath, the combined diphenyleneiodonium nitrate (IV) and silver iodide was collected. The iodonium salt was extracted with boiling water (4 l.) and precipitated by the addition of sodium nitrate. The yield of crude iodonium nitrate, decomposing at 226–228°, was 70%. Several recrystallizations from water raised the decomposition temperature to 240°.

*Anal.* Calcd. for  $C_{12}H_8O_2NI$ : I, 37.32. Found: I, 37.39, 37.41.

The mononitration of the iodonium nitrate was readily accomplished by the use of concentrated sulfuric acid. The nitrate (10 g.) was slowly added with stirring to 30 ml. of concentrated sulfuric acid, cooled in an ice-water-bath. After standing at room temperature for one-half hour, the reaction mixture was poured into 400 ml. of a mixture of ice and water. The 4-nitrodiphenyleneiodonium sulfate (V) precipitated immediately as an orange cream colored solid which was very insoluble in water and alcohol. For purification the salt was extracted several times with boiling water and alcohol. The residue was the pure iodonium compound, decomposing at 268–271°.

*Anal.* Calcd. for  $C_{12}H_7NO_4SI_2$ : S, 4.30. Found: S, 4.38, 4.50.

**4-Nitrodiphenyleneiodonium nitrate (VI)** was obtained when a hot water suspension of the above sulfate was treated with an excess of hot saturated barium nitrate

(4) Sandin, Christiansen, Brown and Kirkwood, *THIS JOURNAL*, **69**, 1650 (1947).

(5) All temperatures are uncorrected.

(6) Mascarelli and Benati, *Gazz. chim. ital.*, **38**, II, 624 (1908); *C. A.*, **3**, 781 (1909). See also Searle and Adams [*THIS JOURNAL*, **55**, 1649 (1933)], who have applied this method successfully to the preparation of 4,4'-dicarboethoxydiphenyleneiodonium iodide.