vent, the growth of I and the solution of II at room temperature is evident. Needles of I bore through plates of II in growing.

20-Ethylcholanthrene appears in the form of thin rhomb-shaped plates, with the acute angle 70°. The extinction is symmetrical or nearly so. The plates yield a biaxial interference figure, +, $r < v$ marked, $2V$ about 40°. Bx_a is inclined to the normal to the plate in the plane of the obtuse diagonal, which is the axial plane. Edge views, obtained with difficulty, show oblique extinction. The crystals are probably monoclinic. The refractive index for vibrations parallel to the acute diagonal (approximately β) is 1.660; for vibrations parallel to the obtuse diagonal (approximately α) 1.640. No evidence of polymorphism was obtained, either on heating or on crystallization from the melt or from solution.

20-Isopropylcholanthrene appears as thin lath-shaped crystals, rectangular in habit, which exhibit parallel extinction flatwise and edgewise. Viewed normal to the principal face, the crystals yield centered biaxial interference figures, +, $2V$ about 40°, with the axial plane crosswise of the crystals, and weak birefringence. Viewed edgewise, the birefringence is stronger. For light vibrating crosswise of the crystals, and travelling normal to their principal face, the refractive index α is about 1.67; for vibrations lengthwise β is 1.69; γ, exhibited by edge views, is higher, estimated at 1.72. No evidence of polymorphism was obtained. The crystals are probably orthorhombic.

Summary

The preparation of 20-isopropylcholanthrene by the method of Fieser and Seligman is described. The formation of α-naphthoic anhydride by the addition of water to an organometallic complex system encountered in this preparation is described. The fluorescence and crystal form of the methyl, ethyl and isopropyl members of this series are recorded.

ITHACA, N. Y. RECEIVED OCTOBER 24, 1938

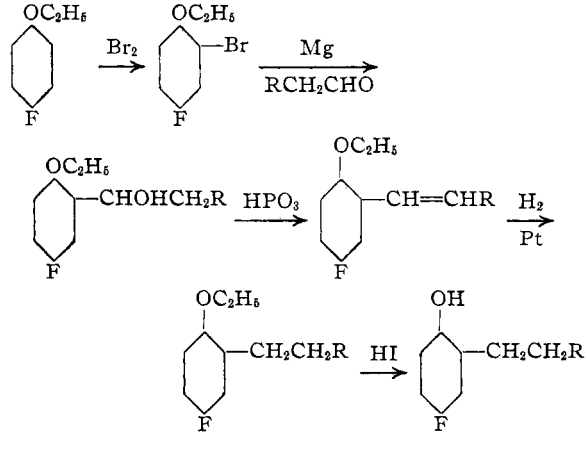
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

The Synthesis and Germicidal Properties of Some Alkylfluorophenols

BY C. M. SUTER, ELMER J. LAWSON AND PERRIN G. SMITH

While the synthesis and bactericidal properties of chloro- and bromoalkylphenols have been investigated extensively,[1] little is known about the corresponding fluorine or iodine derivatives. Because of the marked difference in physiological properties between aliphatic fluorine compounds and those containing other halogens[2] it is of interest to obtain similar information in the aromatic series. The present study deals with the preparation and properties of a series of 2-*n*-alkyl-4-fluorophenols.

Two methods of synthesis were investigated, both starting with *p*-fluorophenetole obtained from *p*-phenetidine by a modification of the method employed by Schiemann and Kühne.[3,4] In the first method, *p*-fluorophenol obtained by deëthylation of *p*-fluorophenetole with aluminum chloride in benzene was utilized in obtaining esters of the normal fatty acids. The esters were converted into hydroxy ketones by the Fries reaction and the latter were reduced with zinc amalgam. Since the yields were poor, particularly for the higher members of the series, a more satisfactory synthesis was sought; the steps involved in the method finally adopted are shown by the accompanying equations.



Bromination of *p*-fluorophenetole gave a crys-

(1) Klarmann, Shternov and Gates, THIS JOURNAL, **55**, 2576 (1933); Klarmann, Gates, Shternov and Cox, *ibid.*, **55**, 4657 (1933).
(2) Henne, *ibid.*, **59**, 1201, 1400 (1937).
(3) Schiemann and Kühne, *Z. physik. Chem.*, **156A**, 414 (1931).
(4) Schiemann, *et al.*, *J. prakt. Chem.*, **143**, 18 (1935).

talline by-product which proved to be 2,4-dibromophenetole. Thermal decomposition of crude *p*-phenetolediazonium borofluoride yields some phenetole which cannot be separated from the fluorine compound.

Attempts to introduce the alkyl group by treating the Grignard reagent of 4-fluoro-2-bromophenetole with *n*-butyl sulfate or *n*-butyl *p*-toluenesulfonate gave unsatisfactory results. Since Klages[5] had shown that vinylphenetoles could not be prepared by dehydration of the corresponding carbinols by the use of acids the *p*-fluoro-*o*-phenetylmethylcarbinol was converted into the chloride and the Grignard reagent of this hydrolyzed with water. A poor yield of the ethylfluorophenetole resulted; the main product of the reaction of magnesium on the chloride was a coupling product. Catalytic reduction of the alkenylfluorophenetoles offered no difficulty despite the observation that fluorine is removed from the ring as the initial step in the hydrogenation of fluorobenzene to cyclohexane[6] with platinum black.

An attempt to deëthylate 4-fluoro-2-*n*-amylphenetole by refluxing with benzene and aluminum chloride gave small amounts of *p*-fluorophenol and of a phenolic compound, m. p. 153–156°, which proved to be identical with a by-product resulting from the reaction of aluminum chloride on *p*-fluorophenetole. The structure of this substance has not been determined. Smith[7] has shown that *p*-*t*-butylphenol with benzene and aluminum chloride yields phenol and *t*-butylbenzene, while Haller[8] prepared 2-isoamylresorcinol in good yields by treating the dimethyl ether with aluminum chloride in toluene. Likewise deëthylation of 2-*n*-butyl-4-fluorophenetole with aluminum chloride in toluene occurred normally. Although the data are not numerous enough to be conclusive toluene seems to be a more suitable solvent than benzene for this reaction.

The bactericidal data[9] indicate that replacing the ring hydrogen of an alkylphenol by fluorine enhances its germicidal properties but that the effect is not as pronounced as with chlorine or bromine. The stock solutions of the phenols above *n*-propyl were made up in 20% alcohol. These were diluted with water to determine the maximum dilutions at which the compounds were effective. The results are summarized in Table I.

TABLE I

2-ALKYL-4-FLUOROPHENOLS

Alkyl	Soly. in H_2O g./liter	Phenol coefficient *B. typhosus*, 20°	Phenol coefficient *Staph. aureus*, 37°
C_2H_5	3.51	10	...
n-C_3H_7	1.95	21	...
n-C_4H_9	0.76[a]	66	60
n-C_5H_{11}	.27[b]	69	139
n-C_6H_{13}	.18[a]	<62	...

[a] In 20% ethyl alcohol. [b] 0.41 in 20% ethyl alcohol.

Upon standing for several months the bactericidal effectiveness of the stock solutions of the phenols was considerably reduced. It was necessary also to redistil samples of the phenols before preparing fresh solutions in order to remove a small amount of non-volatile material. Further study is necessary to determine the cause and the nature of the changes which apparently occur.

Experimental

***p*-Fluorophenetole.**—This was first prepared by Valentiner and Swarts[10] by heating diazotized *p*-phenetidine in strong hydrofluoric acid. Better results were reported[3,4] for the borofluoride method but since details were not given, a description of the modified procedure adopted in this investigation seems desirable.

In a 15 × 20 cm. battery jar fitted with a heavy stirrer and cooled in ice and salt was placed 510 cc. (6 moles) of commercial hydrochloric acid. To this was added slowly with stirring 323 cc. (2.5 moles) of freshly distilled *p*-phenetidine, the addition of a solution containing 175 g. of sodium nitrite in 250 cc. of water being started when about 175 cc. of the *p*-phenetidine had run in. Stirring was continued for fifteen minutes after all the nitrite was in. The solution was kept at 0° throughout the reaction. To this solution was added all at once 1500 cc. of ice cold sodium borofluoride solution (see below) with hand stirring. The pasty mass was kept at 0° for an hour with occasional stirring and then filtered. The solid was washed with 150 cc. of dioxane, then with 300 cc. of ether and air dried.

The sodium borofluoride solution was prepared by adding 1940 g. of commercial 95% sodium fluoride (tinted with Nile blue) in about six portions to a mixture of 2800 cc. of commercial concentrated hydrochloric acid and 680 g. of boric acid in a 5-liter flask. The mixture was shaken vigorously after each addition and after one-half hour the precipitated sodium chloride (and Nile blue) was filtered off giving 3060 cc. of a yellow solution.

The dry diazonium borofluoride was placed in a 5 liter flask fitted with a condenser set for downward distillation. A rubber tube from the side arm of the receiver led below

(5) Klages and Eppelsheim, *Ber.*, **36**, 3585 (1903); Klages, *ibid.*, **37**, 3987 (1904).

(6) Swarts, *Bull. sci. acad. roy. Belg.*, **22**, 122 (1936).

(7) Smith, THIS JOURNAL, **59**, 899 (1937).

(8) Haller, *ibid.*, **55**, 3032 (1933).

(9) We are indebted to Charlotte Epple Smith of the Northwestern University Dental School for the report on the action of these compounds upon *B. typhosus* and to Dr. Maurice L. Moore, Research Laboratory, Sharp and Dohme, for the results obtained with *Staph. aureus*.

(10) Valentiner and Swarts, German Patent, 96,153, *Chem. Zentr.*, **69**, I, 1224 (1898).

the surface of 3 liters of water. The diazonium salt was then heated until it began to decompose vigorously. Usually it was necessary to apply heat intermittently throughout the pyrolysis with strong heating at the end. The distillate was transferred back to the reaction flask, the mixture steam distilled and the organic layer dried and distilled. The yield varied from 35 to 53% of the theoretical amount with the usual yield 150 g. (43%) of material distilling at 54° (7 mm.) or 71° (18 mm.), d^{25}_4 1.061.

p-Fluorophenol.—The procedure used was adapted from that of Schiemann[4] for preparing *o*-fluorophenol from *o*-fluoroanisole. To 35 g. (0.25 mole) of *p*-fluorophenetole in 75 cc. of dry benzene was added 85 g. (0.62 mole) of anhydrous aluminum chloride. After three hours on the steam-bath the mixture was diluted with 200 cc. of benzene and poured on ice. The benzene layer was extracted twice with 100-cc. portions of 20% sodium hydroxide, the alkaline solution acidified and the phenol extracted with ether. Distillation gave 20.7 g. (74%) of *p*-fluorophenol, b. p. 87° (23 mm.). As a residue there remained a solid which crystallized from benzene and melted at 153–156°. From 315 g. of *p*-fluorophenetole 51 g. of this phenolic product was obtained. It has not been identified.

p-Fluorophenyl Esters.—The *p*-fluorophenyl esters of the straight chain fatty acids containing from two to six carbons were prepared by adding a slight excess of the acid chloride to *p*-fluorophenol, warming at 100° to expel the hydrogen chloride and fractionating. The essential data and properties of the esters are listed in Table II.

TABLE II

p-Fluorophenyl ester	Yield, %	B. p., °C.	Mm.	Anal. F, % Calcd.	Found	
Acetate	93	85–87	16	12.3	12.4	12.6
Propionate	92	102–103	19	11.3	11.2	
n-Butyrate	85	124–125	36	10.4	10.5	
n-Valerate	95	120–124	16	9.7	9.4	
n-Caproate	97	134–140	16	9.05	9.0	8.8

About one half of the fluorine analyses of this investigation were made by decomposing the compounds with sodium peroxide in the usual Parr bomb fusion and precipitating the fluorine as lead chlorofluoride.[11] The remaining analyses were made by somewhat modifying a recently described procedure.[12] A 0.05 to 0.06 g. sample of the fluorine compound was decomposed in a semi-micro Parr bomb, the solution of the fusion mixture neutralized and then diluted to 500 ml. A 12.5-ml. portion of this solution was mixed with 15 ml. of 95% ethanol and titrated with thorium nitrate in the presence of the sodium alizarinsulfonate indicator and chloroacetic acid buffer in the usual manner. At this dilution of the fusion mixture it was not necessary to distil before titrating, greatly reducing the time necessary for the analysis. Although this method of fluorine determination does not give results that check as well as might be hoped for, in our experience it is more satisfactory than other methods commonly employed provided the sodium peroxide decomposition is complete. In the case of *p*-fluorophenetole analyses some of the material distilled out of the sodium peroxide and decomposed on the cover and upper wall of the bomb to a carbonaceous material which sometimes retained part of the fluorine. Similar difficulties might be expected with other stable and volatile compounds. The analytical results obtained by the titration procedure are shown in duplicate in the tables, while those found by the lead chlorofluoride method are not.

The calculated molecular refractions were in satisfactory agreement with those observed.

TABLE III

p-Fluorophenyl ester	d^{25}_4	$n^{25}D$	M_D Calcd.	Obsd.
Acetate	1.170	1.4830	37.09	37.4
Propionate	1.128	1.4768	41.71	41.9
n-Butyrate	1.103	1.4729	46.33	46.1
n-Valerate	1.094	1.4832	50.95	51.0
n-Caproate	1.046	1.4719	55.57	56.0

2-Acyl-4-fluorophenols.—The *p*-fluorophenyl esters were isomerized at 150° with anhydrous aluminum chloride according to the method of Klarmann and associates.[1] The ketones were obtained as low melting solids which crystallized readily from 80–90% methanol. The properties of these compounds are listed in Table IV.

TABLE IV

4-FLUORO-2-ACYLPHENOLS

Acyl	Yield, %	B. p., °C.	Mm.	M. p., °C.	Anal. F, % Calcd.	Found	
Acetyl	62	94–99	12	56–56.5	12.3	12.3	
Propionyl	81	117–121	22	30.5	11.3	11.3	11.5
n-Butyryl	83	116–118	14	38–39	10.4	10.8	
n-Valeryl	38	131–135	14	7–9	9.7	9.7	9.6
n-Caproyl	47	146–147	12	49–50	9.1	9.0	

In an attempt to shorten the preparation of 4-fluoro-2-*n*-butyrylphenol, *n*-butyryl chloride was added to the reaction mixture obtained by deëthylating *p*-fluorophenetole and distilling off the benzene. After heating at 150–160° for one and one-half hours, hydrolysis and recovery of the products gave 30% of *p*-fluorophenol, and 25% of the *n*-butyrylphenol. The latter compound forms a sodium salt that is only slightly soluble in aqueous alkali.

An attempt was made to condense *n*-butyryl chloride and *p*-fluorophenetole by aluminum chloride without removing the ethyl group. No reaction occurred using equimolecular quantities of the reagents in olefin-free petroleum ether as a solvent until the temperature reached 60°. After two hours there resulted 44% of *p*-fluorophenetole, 24% of crude *p*-fluorophenyl butyrate, b. p. 95–105° (8 mm.) and 30% of *o*-butyryl-*p*-fluorophenol, b. p. 105–114° (8 mm.). No acylated ether was isolated.

Reduction of 23.6 g. (0.167 mole) of 4-fluoro-2-acetylphenol with 40 g. of amalgamated mossy zinc and a solution made up of 70 cc. of methanol and 200 cc. of dilute (1:2) hydrochloric acid for fifteen hours with occasional addition of more concentrated hydrochloric acid gave 8.3 g. (36%) of a fraction, b. p. 95–105° (26 mm.), which still contained unreduced material as indicated by the red color it gave with ferric chloride. The higher acylfluorophenols gave even poorer yields of crude alkylphenols. Reduction of the valeryl compound with the zinc and acid in the

(11) Specht, *Z. anorg. allgem. Chem.*, **231**, 181 (1937).

(12) Eberz, Lamb and Lachele, *Ind. Eng. Chem., Anal. Ed.*, **10**, 5 (1938). We are indebted to Miss Barbara Roth of this Laboratory for developing the procedure employed and for the analyses made by this method.

presence of toluene gave only tarry products. It is probable that some other modification of the Clemmensen method, perhaps that of Sandulesco and Girard,[13] would give more satisfactory results but this was not investigated.

Bromination of *p*-Fluorophenetole.—*p*-Fluorophenetole was brominated both in acetic acid and in carbon tetrachloride. The latter solvent gave better results. In a 3-liter three-necked flask equipped with a mercury-sealed stirrer, an efficient condenser and a dropping funnel were placed 350 g. (2.5 moles) of *p*-fluorophenetole, 750 cc. of carbon tetrachloride and a few iron tacks. With the mixture at the boiling point there was added 138 cc. (2.6 moles) of bromine over a period of one and one-half hours. After refluxing for an hour longer the mixture was cooled, washed with water and then once with Claisen's solution to remove any phenolic products, dried and distilled. There were obtained 32 g. of unchanged fluorophenetole and 446 g. of bromofluorophenetole, b. p. 108–111° (24 mm.), d^{25}_4 1.0472, n^{25}_D 1.5255. Based on unrecovered fluorophenetole the yield was 90% of the theoretical amount.

Anal. Calcd. for C_8H_8OBrF: Br, 36.5. Found: Br, 36.4.

The combined residues from the bromination of 490 g. of *p*-fluorophenetole practically all distilled at 100–118° (6 mm.). Crystallization from alcohol gave 73 g. of a solid which when pure melted at 52–53°. This proved to be identical with 2,4-dibromophenetole[14] prepared by brominating phenetole in carbon tetrachloride.

Alkyl-2-ethoxy-5-fluorophenylcarbinols.—A Grignard reagent prepared from 292 g. (1.33 moles) of 2-bromo-4-fluorophenetole and 32 g. (1.33 moles) of magnesium turnings in 400 cc. of ether was treated during 1.5 hours with 117 cc. (1.33 moles) of *n*-butyraldehyde dissolved in 300 cc. of ether. The reaction flask was cooled in ice and salt during the addition and then refluxed for one and one-half hours. After hydrolysis with 600 cc. of 10% hydrochloric acid the ether layer was dried and distilled. There was obtained after 54 g. of forerun, 162.6 g. of the carbinol, b. p. 158° (19 mm.). The essential data for this and other carbinols similarly prepared are given in Table V. The ethyl carbinol also was prepared but was dehydrated without purification.

TABLE V

ALKYL-2-ETHOXY-5-FLUOROPHENYLCARBINOLS

Alkyl	Yield, %	B. p., °C.	Mm.	Anal., F Calcd., %	Found, %
Methyl	50	111	6	10.3	9.9
n-Propyl	58	158	19	9.0	8.7
n-Butyl	66	165	15	8.4	8.1
n-Amyl	62	170–172	7	7.9	7.6

TABLE VI

ALKYL-2-ETHOXY-5-FLUOROPHENYLCARBINOLS

Alkyl	d^{25}_4	n^{25}_D	M_D Calcd.	Obsd.
Methyl	1.127	1.4985	47.8	47.9
n-Propyl	1.067	1.4920	57.1	57.7
n-Butyl	1.054	1.4909	61.7	62.2
n-Amyl	1.034	1.4895	66.3	67.2

The densities and refractive indices for the carbinols are listed in Table VI.

2-*n*-Alkenyl-4-fluorophenetoles.—The butenyl, pentenyl and hexenyl compounds were prepared by dehydrating the carbinols with phosphoric acid. A 50-cc. Claisen flask, a condenser and receiver were set up as for the usual vacuum distillation. About 10 cc. of 85% phosphoric acid was placed in the flask and a dropping funnel with a stem reaching to the bottom of the flask was employed to introduce the carbinol. The system was evacuated to about 10 mm., the flask heated in an oil-bath to 200° and the carbinol added dropwise. Not more than 75 g. of carbinol could be dehydrated without cleaning the accumulated tar out of the flask. After all the carbinol had been added the temperature was raised to 260° to remove the last traces of olefin. The clear almost colorless distillate was diluted with ether, the water layer separated and the ether solution dried and fractionated through an efficient column.

The propenylfluorophenetole was made by dehydrating the crude carbinol obtained from 73 g. of 4-fluoro-2-bromophenetole by adding 3 g. of potassium bisulfate and distilling at 27 mm.

Data for the preparation of the alkenylfluorophenetoles are given in Table VII. Irregularities may be due to lack of extensive purification of the olefins.

TABLE VII

2-ALKENYL-4-FLUOROPHENETOLES

Alkenyl	B. p., °C.	Mm.	Yield, %	Anal., F, % Calcd.	Found
n-Propenyl	91–94	6	44	10.5	10.4
n-Butenyl	120–124	13	66	9.8	10.2
n-Pentenyl	108–112	4	85	9.1	9.1
n-Hexenyl	134–138	9	75	8.6	8.1

The discrepancies between calculated and observed values for the molecular refraction are shown in Table VIII. The observed values are consistently higher.

TABLE VIII

2-ALKENYL-4-FLUOROPHENETOLES

Alkenyl	d^{25}_4	n^{25}_D	M_D Calcd.	Obsd.
n-Propenyl	1.037	1.5246	50.5	53.2
n-Butenyl	1.023	1.5145	55.1	57.4
n-Pentenyl	1.008	1.5128	59.7	61.9
n-Hexenyl	0.996	1.5030	64.3	65.7

2-Alkyl-4-fluorophenetoles.—The alkenylfluorophenetoles were reduced according to the following procedure. To a solution of 25 g. of the olefin in 100 cc. of absolute alcohol was added 0.17 g. of platinum oxide catalyst[15] and the mixture was shaken with hydrogen under 30 lb. (2 atm.) initial pressure. The reaction was complete in about ten minutes. After filtering off the platinum black the alcohol was removed through a column and the residual oil fractionated. As shown in Table IX the yields were excellent.

The ethylfluorophenetole was prepared by treating

(13) Sandulesco and Girard, *Bull. soc. chim.*, [4] **47**, 1300 (1930).

(14) Birosel, THIS JOURNAL, **53**, 1409 (1931).

(15) Adams, Voorhees and Shriner, "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1932, p. 452.

18.4 g. (0.1 mole) of the carbinol with dry hydrogen chloride in 250 cc. of toluene at 0° for three hours. The water was removed by distilling off most of the toluene, 100 cc. of dry ether was added and the mixture further dried over potassium carbonate. There was added 2.4 g. (0.1 mole) of magnesium and after no further reaction occurred the mixture was hydrolyzed at 0° with dilute acid. The ether layer was dried and distilled giving 3.7 g. (22%) of 2-ethyl-4-fluorophenetole distilling at 68–68.5° (2.5 mm.). The residue which was the main product was crystallized three times from alcohol giving colorless crystals, m. p. 147.5–148°. The molecular weight by the Rast camphor method was found to be 333. The calculated value for 2,3-*bis*-2-ethoxy-5-fluorophenylbutane is 334.

Anal. Calcd. for $C_{20}H_{24}O_2F_2$: F, 11.37. Found: F, 10.89, 11.07.

TABLE IX

2-ALKYL-4-FLUOROPHENETOLES

Alkyl	Yield, %	B. p., °C.	Mm.	F Anal., % Calcd.	Found	
Ethyl	22	68–68.5	2.5	11.3	11.3	11.3
n-Propyl	97	101–102	16	10.4	10.4	10.9
n-Butyl	96	112–113	14	9.7	9.6	10.2
n-Amyl	87	122–126	11	9.0	8.5	
n-Hexyl	..	107–108	3	8.5	8.4	8.6

The densities and refractive indices are listed in Table X.

TABLE X

2-ALKYL-4-FLUOROPHENETOLES

Alkyl	d^{25}_4	n^{25}_D	M_D Obsd.	Calcd.
Ethyl	1.029	1.4801	46.4	46.3
n-Propyl	1.000	1.4782	51.4	50.9
n-Butyl	0.988	1.4780	55.8	55.5
n-Amyl	.982	1.4797	60.7	60.2
n-Hexyl	.982	1.4820	65.1	64.8

2-Alkyl-4-fluorophenols.—The phenetoles were most satisfactorily converted into the phenols by heating with hydriodic and acetic acids. A 24.8-g. sample of 2-*n*-butyl-4-fluorophenetole was refluxed for fifty-three hours with 150 cc. of 58% hydriodic acid and 175 cc. of glacial acetic acid. The reaction mixture was diluted with water, neutralized with sodium carbonate and then made acid to congo red with hydrochloric acid and extracted several times with benzene. The benzene was then extracted with Claisen's solution and the latter acidified and extracted with ether. Distilling the ether-soluble product gave the pure phenol. The results are given in Table XI.

The phenols were all analyzed by titration with potassium bromate–bromide in acetic acid solution.[16] Since the procedure employed has given satisfactory results for a variety of phenols, a description is appended. Approximately 0.1 g. of the phenol was weighed into a 250-ml. glass-stoppered bottle and 10 ml. of acetic acid added. A slight excess of 0.18 *N* potassium bromate was then added from a 10-ml. buret followed by 0.8 ml. of saturated potassium bromide and 1.5 ml. of 50% sulfuric acid. Enough acetic acid was then added to dissolve any precipitate that had separated, the bottle stoppered and let stand for one-half hour or more. Potassium iodide was then added and the iodine titrated in the usual manner with sodium thiosulfate solution.

(16) The phenol analyses were made by Mr. Sidney Pinhasik working under an N. Y. A. grant.

TABLE XI

2-ALKYL-4-FLUOROPHENOLS

Alkyl	B. p. °C.	Mm.	Yield, %	Anal., $KBrO_3$ titration Equiv. weight Calcd.	Found
Ethyl	64–65	3	52	70.0	68.8
n-Propyl	67.5–68	2.5	63	77.0	77.5
n-Butyl	90.5–91	4	77	84.1	84.5
n-Amyl	104.5–105.5	4	76	91.1	90.7
n-Hexyl	106–107	2.5	72	98.1	97.5

Other physical properties of the phenols are given in Table XII.

TABLE XII

2-ALKYL-4-FLUOROPHENOLS

Alkyl	d^{25}_4	n^{25}_D	M_D Calcd.	Obsd.
Ethyl	1.124	1.5056	36.97	37.1
n-Propyl	1.088	1.5000	41.58	41.7
n-Butyl	1.061	1.4964	46.20	46.3
n-Amyl	1.041	1.4958	50.82	51.1
n-Hexyl	1.032	1.4956	55.44	55.7

2-Alkyl-4-fluorophenoxyacetic Acids.—For purposes of identification the alkylfluorophenols were converted into phenoxyacetic acids by the reaction with sodium chloroacetate in alkaline solution.[17] All of these but the *n*-hexyl compound were satisfactory derivatives. This precipitated as an oil which could not be crystallized. The data for the acids are listed in Table XIII. Not enough of the ethyl and amyl derivatives were available for neutral equivalent determinations.

TABLE XIII

2-Alkyl-4-fluorophenoxyacetic acid	M. p., °C.	Neutral eq. Calcd.	Found
Ethyl	96–97	198.2	...
n-Propyl	73.5–74[a]	212.2	211.3
n-Butyl	73–73.5[a]	226.3	224.5
n-Amyl	63–64	240.3	...

[a] A mixture of the propyl and butyl compounds melted at 63–65°.

4-Fluorophenoxyacetic acid melts at 102–103°.

Anal. Calcd. for $C_8H_7O_3F$: neut. equiv., 170.1. Found: neut. equiv., 170.7.

Summary

1. Two methods of synthesizing 2-*n*-alkyl-4-fluorophenols have been studied. The series from ethyl to *n*-hexyl inclusive has been prepared and some properties of the phenols and of various intermediates have been listed.

2. The bactericidal properties of the alkylfluorophenols are reported briefly. Alkylfluorophenols are more effective germicides under the conditions investigated than are the unsubstituted alkylphenols.

EVANSTON, ILLINOIS RECEIVED NOVEMBER 21, 1938

(17) Koelsch, THIS JOURNAL, 53, 304 (1931).