Fluorothiophenols and Their Derivatives

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o-Fluorothiophenol and its *m*-isomer have been synthesised, and the alkyl or acetonyl fluorophenyl sulfides of these and *p*-fluorothiophenol were prepared. From the acetonyl derivatives quinolines and quinoline carboxylic acids were obtained. Both *m*- and *p*-fluorothiophenols gave the same 3,8-difluorothianthrene, from which the related disulfoxide and disulfone were derived. Methylmercaptofluoroacetophenones and their ω-brominated derivatives were also synthesised, and from the fluoroacetophenones, six cincophen analogs were obtained. Other related compounds prepared and described include methylmercaptofluorobenzophenone, the isomeric fluorophenyl nitrophenyl sulfides and sulfones, related amines and acetylamines, the isomeric monothiobenzoic acid S-(fluorophenyl) esters, S-(fluorophenyl) mercaptoacetic acids and their amides and xanthylamides, and 5,5′-difluorothioindigo.

THE *o*-, *m*- and *p*-fluorothiophenols have been prepared, the two former isomers for the first time. A study has been made of their derivatives.

For the preparation of *o*-fluorothiophenol the only process giving good yields is the diazotization of *o*-fluoroaniline and the formation of its xanthate. To prepare *o*-fluoronitrobenzene, the best process is the reaction of cesium fluoride with *o*-chloronitrobenzene (*1*). Part of the *o*-chloronitrobenzene was transformed to 2,2′-dinitrodiphenyl ether. The reduction of *o*-fluoronitrobenzene was brought about with iron powder and 10% acetic acid.

The *o*-fluorothioanisole was obtained by decomposition of the corresponding diazonium fluoborate in boiling dioxane.

Table I. Derivatives

B.P., °C.	Pressure, Mm. Hg	Yield, %	Formula	Analyses[a] Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Fluorine, % Calcd.	Fluorine, % Found
o-Fluorothiophenol[b]									
65	(15)	57	C_6H_5FS	56.25	56.18	3.9	3.9	14.84	14.86
m-Fluorothiophenol[c]									
53	(11)	54	C_6H_5FS	56.25	56.22	3.9	3.88	14.84	14.82
Methyl *o*-fluorophenyl sulfide[d]									
79–80	(13)	75	C_7H_7FS	59.15	58.96	4.92	4.88	13.38	13.38
Methyl *m*-fluorophenyl sulfide									
69–70	(11)	95	C_7H_7FS	59.15	59.27	4.92	4.91	13.38	13.52
Ethyl *p*-fluorophenyl sulfide									
92–3	(13)	75	C_8H_9FS	61.93	61.82	5.16	5.22	12.25	12.25
n-Propyl *p*-fluorophenyl sulfide									
110–2	(25)	78	$C_9H_{11}FS$	63.52	62.81	6.47	6.33	11.17	11.08
Iso-Propyl *p*-fluorophenyl sulfide									
110	(23)	82	$C_9H_{11}FS$	63.52	63.55	6.47	6.33	11.17	10.92
n-Butyl *p*-fluorophenyl sulfide									
126–8	(23)	73	$C_{10}H_{13}FS$	65.21	65.50	7.07	7.11	10.32	9.91
Iso-Butyl *p*-fluorophenyl sulfide									
118–20	(23)	74	$C_{10}H_{13}FS$	65.21	64.12	7.07	7.09	10.32	10.21
Allyl *p*-fluorophenyl sulfide[e]									
92	(12)	...	C_9H_9FS	64.28	64.24	5.35	5.34	11.30	11.64
β-(*p*-Fluorophenylmercapto) isopropylalcohol									
80–2	(2)	...	$C_9H_{11}FOS$	58.00	57.84	5.91	5.89	10.21	10.19
2-Dimethylamino-1-methyl-ethyl *p*-fluorophenyl sulfide									
90	(0.6)	...	$C_{11}H_{16}FNS$	61.97	62.04	7.51	7.52	8.92	9.03
Acetonyl 2-fluorophenyl sulfide[f]									
145	(18)	75	C_9H_9FOS	58.69	58.57	4.88	4.69	10.32	10.25
Acetonyl 3-fluorophenyl sulfide[g]									
144	(18)	75	C_9H_9FOS	58.69	56.96	4.88	4.62	10.32	9.85
Acetonyl 4-fluorophenyl sulfide[h]									
148	(18)	72	C_9H_9FOS	58.69	59.36	4.88	4.39	10.32	9.83

[a] Analyses were performed by Dr. F. Pascher, Mikroanalytiches Laboratorium, Bonn, W. Germany. [b] $n^{26}D$ 1.5395; lead salts of *o*-, *m*- and *p*-fluorothiophenol have been prepared and are suitable for infrared spectroscopy; the I.R. spectra of *o*-, *m*- and *p*-fluorothiophenol show the absorption of SH at about 3.8 μ. [c] $n^{27}D$ 1.5481. [d] $n^{25}D$ 1.5575. [e] $n^{20}D$ 1.5495. [f] $n^{28}D$ 1.5356; semicarbazone m.p. 153°; thiosemicarbazone m.p. 146°; dinitrophenylhydrazone m.p. 97°. [g] $n^{24}D$ 1.5314; semicarbazone m.p. 118°; thiosemicarbazone m.p. 141; dinitrophenylhydrazone m.p. 126°. [h] $n^{26}D$ 1.5345; semicarbazone m.p. 155°; thiosemicarbazone m.p. 137°; dinitrophenylhydrazone m.p. 239°.

Table II. Derivatives

			Analyses[a]					
			Carbon, %		Hydrogen, %		Fluorine, %	
M.P. °C.	Yield, %	Formula	Calcd.	Found	Calcd.	Found	Calcd.	Found
3,8-Difluorothianthrene[b]								
156	80	$C_{12}H_6F_2S_2$	57.13	57.03	2.37	2.36	15.07	15.05
3,8-Difluorothianthrene disulfoxide								
235	99	$C_{12}H_6F_2O_2S_2$	50.70	50.67	2.11	1.94	13.37	12.64
3,8-Difluorothianthrene disulfone								
270	90	$C_{12}H_6F_2O_4S_2$	45.56	45.61	1.89	2.02	12.01	12.11
Methyl *o*-fluorophenyl sulfone								
49–50	95	$C_7H_7FO_2S$	48.25	48.21	4.02	4.14	10.91	10.87
Methyl *m*-fluorophenyl sulfone								
38	95	$C_7H_7FO_2S$	48.25	48.12	4.02	3.98	10.91	11.02
3,3′-Difluorodiphenyl disulfone								
186	85	$C_{12}H_8F_2O_4S_2$	45.28	45.32	2.51	2.49	11.34	11.22
4-Methylmercapto-3-fluoroacetophenone[c]								
70	90	C_9H_9FOS	58.69	58.66	4.89	4.78	10.32	10.33
4-Methylmercapto-2-fluoroacetophenone[d]								
57	55	C_9H_9FOS	58.69	58.58	4.89	4.85	10.32	10.12
2-Methylmercapto-5-fluoroacetophenone[e]								
50	7	C_9H_9FOS	58.69	59.11	4.89	4.91	10.32	10.09
2-(4′-Methylmercapto-3′-fluorophenyl)-4-quinolinecarboxylic acid**								
201	80	$C_{17}H_{12}FNO_2S$	65.17	64.18	3.83	3.75	6.07	5.98
2-(4′-Methylmercapto-2′-fluorophenyl)-4-quinolinecarboxylic acid**								
228	90	$C_{17}H_{12}FNO_2S$	65.17	64.96	3.83	3.88	6.07	6.26
2-(2′-Methylmercapto-5′-fluorophenyl)-4-quinolinecarboxylic acid**								
222	85	$C_{17}H_{12}FNO_2S$	65.17	66.11	3.83	3.71	6.07	6.06
4-Methylmercapto-3-fluorobenzophenone[f]								
49	99	$C_{14}H_{11}FOS$	68.29	67.98	4.47	4.33	7.72	7.71
4-Methylmercapto-2-fluorobenzophenone[g]								
64	50	$C_{14}H_{11}FOS$	68.29	69.11	4.47	4.36	7.72	7.48
2-Methylmercapto-5-fluorobenzophenone[h]								
99	30	$C_{14}H_{11}FOS$	68.29	67.94	4.47	4.36	7.72	7.52
2-Fluorophenyl 4′-nitrophenyl sulfide								
78	98	$C_{12}H_8FNO_2S$	57.83	56.66	3.21	3.12	7.63	7.58
3-Fluorophenyl 4′-nitrophenyl sulfide								
71	90	$C_{12}H_8FNO_2S$	57.83	56.98	3.21	3.22	7.63	7.60
4-Fluorophenyl 4′-nitrophenyl sulfide								
95	95	$C_{12}H_8FNO_2S$	57.83	56.98	3.21	3.33	7.63	7.63
2-Fluorophenyl 4′-nitrophenyl sulfone								
165	99	$C_{12}H_8FNO_4S$	51.24	50.39	2.84	2.72	6.76	6.66
3-Fluorophenyl 4′-nitrophenyl sulfone								
140	95	$C_{12}H_8FNO_4S$	51.24	50.82	2.84	2.45	6.76	6.63
4-Fluorophenyl 4′-nitrophenyl sulfone								
160	95	$C_{12}H_8FNO_4S$	51.24	50.64	2.84	2.69	6.76	6.82
2-Fluorophenyl 4′-aminophenyl sulfone[i]								
159	70	$C_{12}H_{10}FNO_2S$	57.37	57.47	3.98	3.68	7.56	7.71
3-Fluorophenyl 4′-aminophenyl sulfone[j]								
173	70	$C_{12}H_{10}FNO_2S$	57.37	56.86	3.98	3.89	7.56	7.55
4-Fluorophenyl 4′-aminophenyl sulfone[k]								
203	75	$C_{12}H_{10}FNO_2S$	57.37	57.44	3.98	3.99	7.56	7.44
Monothiobenzoic acid-S-(2-fluorophenyl)ester								
64	70	$C_{13}H_9FOS$	67.24	67.11	3.87	3.77	8.18	8.22
Monothiobenzoic acid-S-(3-fluorophenyl)ester								
48	72	$C_{13}H_9FOS$	67.24	66.88	3.87	3.88	8.18	8.31
Monothiobenzoic acid-S-(4-fluorophenyl)ester								
47–8	75	$C_{13}H_9FOS$	67.24	66.92	3.87	3.66	8.18	8.21
S-(2-Fluorophenyl)mercapto acetic acid								
79	70	$C_8H_7FO_2S$	51.60	51.55	3.76	3.62	10.21	9.72
S-(3-Fluorophenyl)mercapto acetic acid[l]								
71	75	$C_8H_7FO_2S$	51.60	51.52	3.76	3.66	10.21	9.73
S-(4-Fluorophenyl)mercapto acetic acid[m]								
73	74	$C_8H_7FO_2S$	51.60	51.50	3.76	3.66	10.21	10.34
S-(2-Fluorophenyl)mercapto acetamide[n]								
89	76	C_8H_8FNOS	51.89	52.06	4.32	4.43	10.27	10.23
S-(3-Fluorophenyl)mercapto acetamide[o]								
102	72	C_8H_8FNOS	51.89	52.31	4.32	4.41	10.27	9.98
S-(4-Fluorophenyl)mercapto acetamide[p]								
118	73	C_8H_8FNOS	51.89	52.33	4.32	4.21	10.27	10.29
5,5′-Difluorothioindigo								
400***	55	$C_{16}H_6F_2O_2S_2$	57.38	57.63	1.8	1.8	11.44	11.34

(Continued on page 278)

Table II. Derivatives(*Continued*)

M.P. °C.	Yield, %	Formula	Analyses[a] Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Fluorine, % Calcd.	Fluorine, % Found
2-(2′-Fluorothioanisyl)-4-quinolinecarboxylic acid								
282*	98	$C_{17}H_{12}FNO_2S$	65.17	65.15	3.83	3.92	6.07	5.96
2-(3′-Fluorothioanisyl)-4-quinolinecarboxylic acid								
282*	98	$C_{17}H_{12}FNO_2S$	65.17	64.91	3.83	3.72	6.07	6.17
2-(4′-Fluorothioanisyl)-4-quinolinecarboxylic acid								
313*	96	$C_{17}H_{12}FNO_2S$	65.17	64.98	3.83	3.71	6.07	6.18
2-(2′-Fluorothioanisyl)quinoline[q]								
68	75	$C_{16}H_{12}FNS$	71.37	71.62	4.46	4.42	7.06	6.98
2-(3′-Fluorothioanisyl)quinoline[r]								
78	70	$C_{16}H_{12}FNS$	71.37	70.44	4.46	4.36	7.06	6.89
2-(4′-Fluorothioanisyl)quinoline[s]								
72	70	$C_{16}H_{12}FNS$	71.37	72.41	4.46	4.57	7.06	6.82

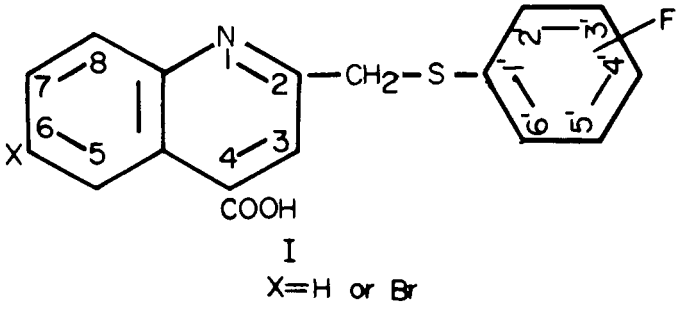
* Decarbox. ** Cincophen analogs. *** Sublim. [a] Melting points were corrected. [b] With sulfuric acid gave an intense violet color, with absorption at 380mμ. [c] B.p. 135° (2.5 mm.); semicarbazone, m.p. 216°; dinitrophenylhydrazone, m.p. 174°. [d] Semicarbazone, m.p. 184°; dinitrophenylhydrazone, m.p. 174°. [e] Semicarbazone, m.p. 161°; dinitrophenylhydrazone, m.p. 225°. [f] B.p. 200°(15 mm.); dinitrophenylhydrazone, m.p. 178°. [g] Dinitrophenylhydrazone, m.p. 187°. [h] Dinitrophenylhydrazone, m.p. 230°. [i] Acetylamine, m.p. 192°. [j] Acetylamine, m.p. 165°. [k] Acetylamine, m.p. 184°. [l] β-Naphthyl ester, m.p. 67°. [m] β-Naphthyl ester, m.p. 65°. [n] Xanthylamide, m.p. 167°. [o] Xanthylamide, m.p. 170°. [p] Xanthylamide, m.p. 174° [q] Picrate, m.p. 184°. [r] Picrate, m.p. 168°. [s] Picrate, m.p. 196°.

Table III. Derivatives

M.P. °C.	Yield, %	Formula	Br, % Calcd.	Br, % Found
ω-Bromo-4-methylmercapto-3-fluoroacetophenone				
71	...	C_9J_8BrFOS	30.41	30.41
ω-Bromo-4-methylmercapto-2-fluoroacetophenone				
63	...	C_9H_8BrFOS	30.41	30.62
6-Bromo-2-(4′-methylmercapto-3′-fluorophenyl)-4-quinolinecarboxylic acid**				
250*	85	$C_{17}H_{11}BrFNO_2S$	20.04	20.19
6-Bromo-2-(4′-methylmercapto-2′-fluorophenyl)-4-quinolinecarboxylic acid**				
240*	80	$C_{17}H_{11}BrFNO_2S$	20.04	20.21
6-Bromo-2-(2′-methylmercapto-5′-fluorophenyl)-4-quinolinecarboxylic acid**				
181*	85	$C_{17}H_{11}BrFNO_2S$	20.04	20.08
6-Bromo-2-(2′-fluorothioanisyl)4-quinolinecarboxylic acid				
288*	95	$C_{17}H_{11}BrFNO_2S$	20.04	20.05
6-Bromo-2-(3′-fluorothioanisyl)-4-quinolinecarboxylic acid				
280*	95	$C_{17}H_{11}BrFNO_2S$	20.04	20.05
6-Bromo-2-(4′-fluorothioanisyl)-4-quinolinecarboxylic acid				
300*	96	$C_{17}H_{11}BrFNO_2S$	20.04	19.65
6-Bromo-2-(2′-fluorothioanisyl)quinoline[a]				
85	70	$C_{16}H_{11}BrFNS$	22.99	23.08
6-Bromo-2-(3′-fluorothioanisyl)quinoline[b]				
79	73	$C_{16}H_{11}BrFNS$	22.99	23.48
6-Bromo-2-(4′-fluorothioanisyl)quinoline[c]				
99	75	$C_{16}H_{11}BrFNS$	22.99	23.08

* Decarbox. ** Cincophen analogs. [a] Picrate, m.p. 202°. [b] Picrate, m.p. 170°. [c] Picrate, m.p. 199°.

The 2-(2′-fluorothioanisyl) 4-quinolinecarboxylic acid and its *m*- and *p*-isomers (I) were prepared by the reaction of isatin with the corresponding acetonyl fluorophenyl sulfide in boiling alcoholic potassium hydroxide.



I

X=H or Br

While sulfur trioxide in sulfuric acid at room temperature produced sulfonation of *o*-fluorothiophenol, it caused in both *m*- and *p*-isomers the formation of the same product: 3,8-difluorothianthrene.

The data of these new compounds are given in Tables I, II and III.

LITERATURE CITED

(1) Vorozhtov, N.N., Jr., and Yakobson G.G., *Khim. Nauka i Prom.*, 3, 403 (1958); C.A., 19988 (1958).

RECEIVED for review September 4, 1962. Accepted January 3, 1963.