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AROMATIC POLYFLUORO COMPOUNDS—XXXIV[1]

NUCLEOPHILIC REPLACEMENT REACTIONS OF SOME TETRAFLUOROHALOGENOBENZENES

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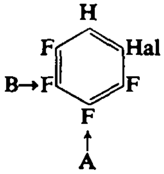
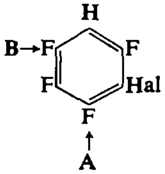
Abstract—The 1,2,3,4-tetrafluoro-5-halogenobenzenes react with sodium methoxide or dimethylamine with replacement mainly of the fluorine *para* to the hydrogen. The fluorine *para* to the halogen is also replaced, and to an extent which increases in the order: (Halogen =) Cl < Br < I, but which is always less than the replacement *para* to the hydrogen. The reactions of the 1,2,3,5-tetrafluoro-4-halogenbenzenes with sodium methoxide follow the same pattern, but with dimethylamine replacement *para* to the halogen predominates when the halogen is bromine or iodine. A rationalization of these results, based on electron repulsion by halogens and a steric effect, is advanced.

It has been predicted[2] that the two types of tetrafluorohalogenobenzenes indicated below would be attacked by nucleophiles mainly at position A, and also that attack at B would increase in the sequence: (Hal =) Cl < Br < I, but, at least with compounds of type I, would always be less than at A. It was also suggested that with the compounds of type II attack at A might be sterically hindered, particularly when the halogen is iodine. These predictions have now been tested for all six compounds [Hal = Cl, Br, I for (I) and (II)], each with sodium methoxide and dimethylamine as nucleophiles.



I, a, Hal = Cl
b, Hal = Br
c, Hal = I



II, a, Hal = Cl
b, Hal = Br
c, Hal = I

RESULTS

Four of the six tetrafluorohalogenobenzenes required had been prepared before. Wall *et al.*[3] converted 2-chloroheptafluorotoluene into 2-chloropentafluorobenzoic acid by hydrolysis and then decarboxylated this to give the chloro-compound (Ia). In this department[4] the bromo- and iodo-compounds (Ib and Ic) have been prepared by the addition of lithium bromide and iodide, respectively, to tetrafluorobenzyne, followed by hydrolysis; and finally, Tilney-Bassett[5] selectively reduced the 1,2- and

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[1] Part XXXIII. P. L. Coe, A. E. Jukes and J. C. Tatlow, submitted to *J. Chem. Soc.*

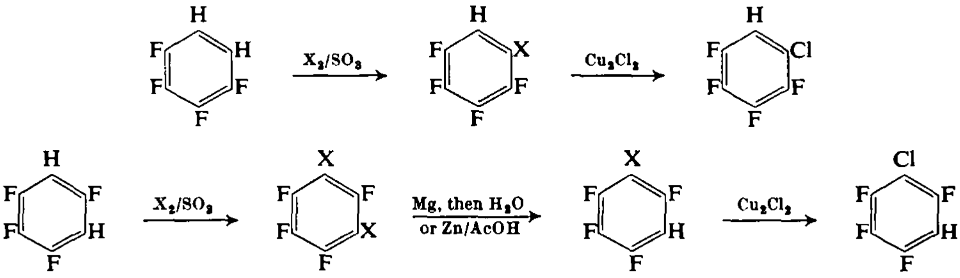
[2] J. Burdon, *Tetrahedron* **21**, 3373 (1965).

[3] W. J. Pummer, L. A. Wall and R. E. Florin, *J. Res. Natl. Bur. Standards* **62**, 113 (1959).

[4] D. D. Callander, P. L. Coe and J. C. Tatlow, *Tetrahedron* **22**, 419 (1966).

[5] J. F. Tilney-Bassett, *Chem & Ind.* 693 (1965).

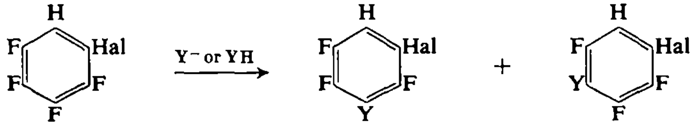
1,3-dibromotetrafluorobenzenes with zinc and acetic acid to the bromo-compounds (Ib and IIb) respectively. We have, in fact, utilized only the last of these procedures as we found the methods outlined in the scheme to be more convenient.



Contrary to a previous report[5], 1,2,3,4-tetrafluorobenzene can be mono-brominated or mono-iodinated in good yield with bromine or iodine in oleum. We were not, however, able to extend the reaction to the 1,2,3,5-tetrafluorobenzene series; mixtures of mono- and di-brominated (or iodinated) products were formed instead. We therefore prepared the monobromo-compound (IIb) by the zinc/acetic acid procedure[5] from the dibromo-compound. The iodo-compound (IIc) was produced by converting the di-iodo compound into its mono-Grignard reagent and then hydrolysing. Both chloro compounds (Ia and IIa) were prepared by treatment of the corresponding monobromo-compounds with cuprous chloride in dimethylformamide, a procedure first established in the polyfluoro-aromatic field by Buxton *et al.*[6] Several of the tetrafluorohalogenobenzenes were also prepared by other procedures, which are detailed in the experimental section.

Each of the six tetrafluorohalogenobenzenes has been treated with the nucleophiles sodium methoxide and dimethylamine. In every case products of two main types (III and IV from I, and V and VI from II) were detected. Occasionally, other products, possibly di-substituted materials or compounds produced from attack at positions other than A or B (cf. I and II), were present; they were, however, always much less in amount than III–VI and have been neglected.

None of the six reaction mixtures from the 1,2,3,4-tetrafluoro-5-halogenobenzenes (I) were separable into their components (III and IV) by gas chromatography and so elemental analyses and NMR measurements were carried out with mixtures. The



I III IV

Y = OMe, NMe_2

relative amounts and the structures of III and IV were determined from the PMR spectra. The methoxyl and dimethylamino signals of both III and IV were, as expected,[7] split into triplets (by coupling to two *ortho*-fluorines) and so did not permit these compounds to be distinguished; they did, however, confirm that the products, were, in

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[6] L. J. Belf, M. W. Buxton and G. Fuller, *J. Chem. Soc.* 3372 (1965).

[7] J. Burdon, *Tetrahedron* **21**, 1101 (1965).

fact, III and IV and not those that would have been formed by nucleophilic attack at the other two positions (these would give singlets[8] or doublets[7]). As the methoxyl or dimethylamino signals of III and IV were well separated in every case, the relative amounts of these compounds could be determined from their relative intensities; the figures are given in Table 1.

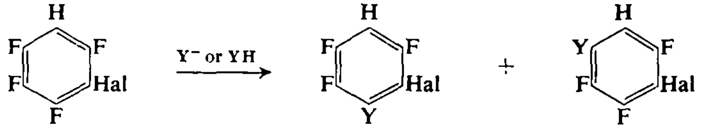
TABLE 1. PRODUCT COMPOSITION IN NUCLEOPHILIC REACTIONS OF TETRAFLUOROHALOGENOBENZENES

Starting material	Nucleophile	%[a] attack *para* to H	%[a] attack *para* to Hal
1-Cl-2,3,4,5-C_6F_4H	Me_2NH	86	14
1-Cl-2,3,4,5-C_6F_4H	NaOMe	85	15
1-Cl-2,3,4,6-C_6F_4H	Me_2NH	60	40
1-Cl-2,3,4,6-C_6F_4H	NaOMe	86	14
1-Br-2,3,4,5-C_6F_4H	Me_2NH	75	25
1-Br-2,3,4,5-C_6F_4H	NaOMe	78	22
1-Br-2,3,4,6-C_6F_4H	Me_2NH	33	67
1-Br-2,3,4,6-C_6F_4H	NaOMe	80	20
1-I-2,3,4,5-C_6F_4H	Me_2NH	60	40
1-I-2,3,4,5-C_6F_4H	NaOMe	60	40
1-I-2,3,4,6-C_6F_4H	Me_2NH	8	92
1-I-2,3,4,6-C_6F_4H	NaOMe	60	40

[a] Accuracy ca. ±4%.

The structures of all the III and IV compounds were determined from the coupling patterns shown by the aromatic proton signals. In both sets of compounds these signals consisted of doublets of doublets of doublets and all the coupling constants could easily be measured from the spectra in spite of the fact that these usually overlapped to some extent. The parameters are listed in Tables 3 and 5. In every case IV could be unmistakably distinguished from III by the presence of a *para* H—F coupling constant (J^{para}_{HF}) which always lay in the 2–3 c/s range. This range is the same as that observed in all the substrate tetrafluorohalogenobenzenes (Table 2) and in other fluoroaromatic compounds,[9] and is considerably smaller than any of the J^{ortho}_{HF} or J^{meta}_{HF} values recorded in this or in previous work.[9]

The products V and VI from the 1,2,3,5-tetrafluorohalogenobenzenes were separable by gas-chromatography, in contrast to their isomers III and IV, and so NMR structural determinations could be carried out on single compounds. Once again the product ratios were determined from the relative intensities of the methoxyl or dimethylamino signals in the PMR spectra of the reaction mixtures and are recorded in Table 1. Again analogously, V and VI were distinguished in every case



II V VI

Y = OMe, NMe_2

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[8] J. Burdon and W. B. Hollyhead, *J. Chem. Soc.* 6326 (1965).

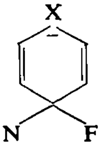
[9] H. S. Gutowsky, C. H. Holm, A. Saika and G. H. Williams, *J. Amer. Chem. Soc.* **79**, 4596 (1957).

by the 2–3 c/s coupling constants (attributable to J_{HF}^{para}) observed in the aromatic proton signals of VI but not V (Tables 3 and 5). In the sodium methoxide reactions, V and VI were also distinguishable by the fine structures of the methoxyl proton signals; those from compounds V (one *ortho*-fluorine but no *ortho*-hydrogen present) were doublets, and those from VI single lines[8] (*ortho*-hydrogen present). The methyl proton signals of the dimethylamino compounds (V and VI) were all split into doublets[7,8] and so were useless for this purpose.

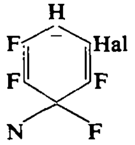
The largest coupling constants for III–VI and for the substrates (Tables 2, 3 and 5) fall into the range 7·8–11·9 c/s and are assigned to J_{HF}^{ortho}; this range is similar to that observed in other fluoro-aromatic compounds.[9] The remaining coupling constants for III-VI and the substrates must be J_{HF}^{meta} values, and they fall in the range 5·2–8·2 c/s. When the intervening carbon atom bears an iodine, J_{HF}^{meta} is at the lower end of this range (5·2–6·2 c/s) and there seems to be a slight tendency for J_{HF}^{meta} to increase as the intervening carbon bears, successively, bromine, chlorine and fluorine.

DISCUSSION

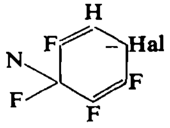
The predictions referred to in the introduction were based on a consideration[2] of species of type VII which were taken as models of the transition states involved in nucleophilic aromatic substitutions. Other resonance contributors were ignored to a first approximation. The effect of the substituent X on the stability of the adjacent negative charge was then considered, and it was argued[2] that such a charge would be destabilised in the order: (X =) F > Cl > Br > I ~ H. This is ascribed to repulsion (I_π repulsion) between the lone electron pairs on the halogens and the negative charge (which is in a π-electron system); I_π repulsion is known from UV measurements[10] to increase in the order H ~ I < Br < Cl < F. Applied to the present series of compounds, therefore, this means that VIII is more stable than IX, which is more stable than X. Replacement *para* to the hydrogen should therefore predominate in all cases, which it does (Table 1). The smaller the difference between the I_π repulsions of a halogen and hydrogen, the smaller becomes the difference between the stabilities of VIII and IX. This therefore leads, and is borne out by the figures in Table 1, to an increase in reaction *via* transition state (IX) as the halogen changes from chlorine to bromine and then to iodine.



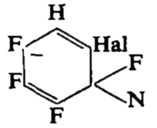
VII



VIII

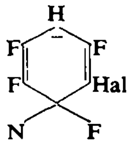


IX

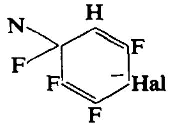


X

N = nucleophile



XI



XII

N = nucleophile

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[10] D. P. Craig and G. Doggett, *Mol. Phys.* **8**, 485 (1964); D. T. Clark, J. N. Murrell and J. M. Tedder, *J. Chem. Soc.* 1250 (1963).

The reactions of the compounds (II) can be partially rationalized in the same way. The observed main attack *para* to the hydrogen proceeds through a transition state similar to XI and the secondary attack (increasing in the expected order Cl < Br < I) at the position *para* to the halogen through one of type XII. As can be seen from Table 1, however, this only applies completely to the sodium methoxide reactions, where the figures are almost the same as those found for the 1,2,3,4-tetrafluoro-5-halogenobenzenes (I).

The dimethylamine reactions do not follow the same pattern; with the chloro compound (IIa) the trend towards main attack *para* to the hydrogen is still preserved, but is not as marked as in the other three reactions of the chloro substrates. The bromo and iodo compounds (IIb and IIc), however, are attacked mainly at the position *para* to the halogen by dimethylamine in contradiction to the electronic argument advanced above. We attribute this to a primary steric effect between the halogen and dimethylamine. It increases with increasing size of halogen, and the effect seems to be negligible with the smaller sodium methoxide. A similar steric phenomenon has been observed with the same nucleophile by Russian workers.[11] They found that pentachlorobenzene was attacked mainly at the position *para* to the hydrogen by ammonia (this can be rationalized electronically[2]), but mainly at the more accessible *ortho*-position by the larger dimethylamine.

When Hal = F, both I and II are pentafluorobenzene. The equivalent of attack at A (cf I and II in the introduction) is attack at the position *para* to the hydrogen; in fact[12] well over 90% of the products from the reactions of pentafluorobenzene and sodium methoxide or dimethylamine are formed by such attack. The equivalent of attack at B is attack on one of the *meta* positions of pentafluorobenzene in case (I), and on one of the *ortho* in II. The actual amounts of *ortho* and *meta* replacement in pentafluorobenzene are <5% and <3%, respectively,[12] and this is in line with the electronic arguments advanced above, as there is more difference between the I_π repulsion of hydrogen and fluorine than between hydrogen and any other halogen.

EXPERIMENTAL

1-*Bromo*-2,3,4,5-*tetrafluorobenzene* (Ib). 1,2,3,4-Tetrafluorobenzene (10 g) was added dropwise, with stirring, to a cooled (0°) solution of Br_2 (20 g) and $AlBr_3$ (0·1 g) in oleum (20% SO_3: 30 ml). After a further 5 hr at 0°, the reaction mixture was poured into ice and the product was isolated by ether extraction; GLC showed that >95% of it was the required monobromo compound. Distillation gave 1-bromo-2,3,4,5-tetrafluorobenzene (8·0 g), b.p. 137°. (Found: C, 31·4; H, 0·4. Calc. for C_6HBrF_4: C, 31·5; H, 0·4%.)

1-*Bromo*-2,3,4,6-*tetrafluorobenzene* (IIb). 1,2,3,5-Tetrafluorobenzene (10 g) was treated with Br_2 and oleum as in the previous experiment. However, GLC showed that the crude product (14 g) was mainly the dibromo product (still true when even less Br_2 was used). This was refluxed for 2 hr with glacial AcOH (10 ml) and powdered Zn[6] (3 g), then poured into $NaHCO_3$aq and the product extracted with ether; it was 1-bromo-2,3,4,6-tetrafluorobenzene (10 g), b.p. 142°. (Found: C, 31·7; H, 0·5%.)

1,2,3,4-*Tetrafluoro*-5-*iodobenzene* (Ic). 1,2,3,4-Tetrafluorobenzene (10 g) was added dropwise with stirring, to a cooled (0°) solution of I_2 (18 g) in oleum (20% SO_3; 30 ml). After a further hr at 0°, the reaction mixture was worked up as in the first experiment to give 1,2,3,4-tetrafluoro-5-iodobenzene (12 g), b.p. 164° (lit[4]., 159–160°). (Found: C, 26·2; H, 0·5. Calc. for C_6HF_4I: C, 26·1; H, 0·4%.)

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[11] L. S. Kobrina, G. G. Yakobson and N. N. Vorozhtsov, *Zh. Obshch. Khim.* **35**, 137 and 142 (1965).

[12] J. Burdon, P. L. Coe, C. R. Marsh and J. C. Tatlow *Tetrahedron* **22**, 1183 (1966); G. M. Brooke, J. Burdon and J. C. Tatlow *J. Chem. Soc.* 3253 (1962).

1,2,3,5-*Tetrafluoro-4-iodobenzene* (IIc). 1,2,3,5-Tetrafluorobenzene (10 g) was treated with I_2 and oleum as in the previous experiment. GLC showed that the crude product was mainly 1,2,3,5-tetrafluoro-4,6-di-iodobenzene. This was added dropwise, with stirring to Mg (20 g) (previously activated by treatment with EtBr) in dry tetrahydrofuran (15 ml), under an atmosphere of N_2 and at 0°. Stirring was continued for 30 min after the addition has been completed, and then water (20 ml) was added followed by dil. H_2SO_4 (30 ml). Extraction with ether yielded 1,2,3,5-*tetrafluoro-4-iodobenzene* (7 g), b.p. 166°. (Found: C, 26·2; H, 0·5%.)

1-*Chloro*-2,3,4,5-*tetrafluorobenzene* (Ia). 1-Bromo-2,3,4,5-tetrafluorobenzene (8 g), Cu_2Cl_2 (10 g) and dry dimethylformamide (20 ml) were refluxed for 6 hr. The reaction mixture was poured into water, filtered and the precipitate was washed well with ether and the filtrate was extracted with the same solvent. Evaporation of the dried ($MgSO_4$), combined ethereal washings and extracts left a residue which, according to GLC, contained only a small amount of the starting bromo compound. Distillation gave 1-chloro-2,3,4,5-tetrafluorobenzene (4 g), b.p. 120° (lit.[3] 122–123°). (Found: C, 39·2; H, 0·5. Calc. for C_6HClF_4: C, 39·1; H, 0·5%.)

Treatment of a solution of Li 2,3,4,5-tetrafluorophenyl (from 1,2,3,4-tetrafluoro-5-iodobenzene and LiBu) in ether with liquid Cl_2 at −78° gave a 20% yield of monochloro compound.

1-*Chloro*-2,3,4,6-*tetrafluorobenzene* (IIa). This was prepared in 60% yield by treatment of 1-bromo-2,3,4,6-tetrafluorobenzene with Cu_2Cl_2 in dimethylformamide as described. The product had b.p. 118°. (Found; C, 38·9; H, 0·8%.)

Treatment of 1,3-dichloro-2,4,5,6-tetrafluorobenzene with Zn and glacial AcOH gave only a 2% yield of the monochloro compound after 10 hr refluxing.

Treatment of the Grignard reagent from this same dichloro compound (prepared as described above for 1,2,3,5-tetrafluoro-4,6-di-iodobenzene) with water gave a 90% yield of the monochloro compound.

PMR spectra of the tetrafluorohalogeno-benzenes are recorded in Table 2.

TABLE 2

Compound	δ[a]	J_1[b]	J_2[b]	J_3[b]	J_4[b]
1-Cl-2,3,4,5-C_6F_4H	6·7	10·0	7·4	6·4	2·7
1-Cl-2,3,4,6-C_6F_4H	6·6	10·7	9·3	6·8	2·7
1-Br-2,3,4,5-C_6F_4H	7·2	10·0	7·9	6·2	2·7
1-Br-2,3,4,6-C_6F_4H	6·8	10·3	8·4	6·3	2·5
5-I-1,2,3,4-C_6F_4H	7·4	9·2	7·7	5·2	2·7
4-I-1,2,3,5-C_6F_4H	6·9	10·1	7·8	6·0	2·5

[a] Chemical shifts (neat liquids) in ppm downfield from TMS as external reference.

[b] Coupling constants (in c/s) arranged in decreasing order of magnitude (see results section for assignments).

Reaction of tetrafluorohalogenobenzenes with dimethylamine. The tetrafluorohalogenobenzene (1·5 g), dimethylamine (2 moles of a 33% w/w solution in EtOH) and dry MeOH (5 ml) were heated in a sealed tube at 100° for 12 hr. The reaction mixture was poured into water and the crude products were isolated by ether extraction (yields >90%). These products were analysed by ^1H NMR (compositions in Table 1, parameters in Table 3) and then distilled (b.ps and elemental analyses of the mixtures in Table 4). The products from the 1,2,3,5-tetrafluoro-4-halogenobenzenes were separated by GLC (on a column packed with silicone gum on Celite) and their identities were confirmed by the ^1H and ^{19}F NMR spectra of the separated isomers (which were usually liquids). The products from the 1,2,3,4-tetrafluoro-5-halogenobenzenes could not be separated by GLC.

Reaction of tetrafluorohalogenobenzenes with sodium methoxide in methanol. The tetrafluorohalogenobenzene (1·5 g) was refluxed for 3 hr with 0·5N MeONa in MeOH (1 mol). The reaction mixture was poured into water and the crude products isolated by ether extraction (yields >95%).

TABLE 3. ^{1}H NMR SPECTRA[a] OF DIMETHYLAMINOTRIFLUOROHALOGENOBENZENES

Compound	$(CH_3)_2$N-peaks		Nuclear H peaks			
	δ[b]	J	δ[b]	J_1[d]	J_2[d]	J_3[d]
1-Cl-3-NMe$_2$-2,4,5-C$_6$F$_3$H	2·6	2·1(T)	6·4	9·8	8·0	6·6
1-Cl-4-NMe$_2$-2,3,5-C$_6$F$_3$H	2·6	1·6(T)	6·4	11·8	7·7	2·3
1-Cl-2-NMe$_2$-3,4,6-C$_6$F$_3$H	2·7	2·8(D)	6·3	10·0	8·8	6·8
1-Cl-4-NMe$_2$-2,3,6-C$_6$F$_3$H	2·7	1·8(D)	6·0	11·9	7·5	2·3
1-Br-3-NMe$_2$-2,4,5-C$_6$F$_3$H	2·9	2·0(T)	6·9	9·3	8·0	6·2
1-Br-4-NMe$_2$-2,3,5-C$_6$F$_3$H	2·9	—	6·9	11·6	6·2	2·6
1-Br-2-NMe$_2$-3,4,6-C$_6$F$_3$H	2·8	2·6(D)	6·6	10·4	8·5	6·8
1-Br-4-NMe$_2$-2,3,6-C$_6$F$_3$H	2·9	1·6(D)	6·2	11·2	7·4	2·4
1-NMe$_2$-5-I-2,3,6-C$_6$F$_3$H	3·0	2·2(T)	7·0	9·1	8·2	5·5
1-NMe$_2$-4-I-2,3,6-C$_6$F$_3$H	3·0	2·2(T)	7·0	11·5	5·6	2·6
1-NMe$_2$-6-I-2,3,5-C$_6$F$_3$H	2·9	2·4(D)	6·8	10·5	9·5	7·5
1-NMe$_2$-4-I-2,3,5-C$_6$F$_3$H	3·0	1·7(D)	6·4	11·0	7·2	2·2

[a] Of crude liquids.

[b] Chemical shifts in ppm downfield from TMS as external reference.

[c] Coupling constant (c/s); S = singlet; D = doublet; T = triplet.

[d] Coupling constants (c/s); all signals were doublets of doublets of doublets; the J's are recorded in decreasing order of magnitude—see results section for further assignments.

TABLE 4. TETRAFLUOROHALOGENOBENZENES AND DIMETHYLAMINE

Compounds	b.p.	Analysis			
		Calc		Found	
		%C	%H	%C	%H
1-Cl-3-NMe$_2$-2,4,5-C$_6$F$_3$H	185°	45·8	3·4	45·8	3·4
1-Cl-4-NMe$_2$-2,3,5-C$_6$F$_3$H					
1-Cl-2-NMe$_2$-3,4,6-C$_6$F$_3$H	165°	45·8	3·4	46·0	3·6
1-Cl-4-NMe$_2$-2,3,6-C$_6$F$_3$H	222°				
1-Br-3-NMe$_2$-2,4,5-C$_6$F$_3$H	216°	37·8	2·8	37·5	2·8
1-Br-4NMe$_2$-2,3,5-C$_6$F$_3$H					
1-Br-2-NMe$_2$-3,4,6-C$_6$F$_3$H	184°	37·8	2·8	37·4	2·8
1-Br-4-NMe$_2$-2,3,6-C$_6$F$_3$H	>230°				
1-NMe$_2$-5-I-2,3,6-C$_6$F$_3$H	>230°	31·9	2·3	31·9	2·3
1-NMe$_2$-4-I-2,3,6-C$_6$F$_3$H					
1-NMe$_2$-6-I-2,3,5-C$_6$F$_3$H	—	31·9	2·3	31·7	2·5
1-NMe$_2$-4-I-2,3,5-C$_6$F$_3$H	[a]				

[a] m.p. 49°

TABLE 5. ^{1}H NMR SPECTRA[a] OF TRIFLUOROHALOGENOMETHOXYBENZENES

Compound	MeO-peaks		Nuclear H peaks			
	δ^b	J^c	δ^b	J_1^d	J_2^d	J_3^d
1-Cl-3-OMe-2,4,5-C_6F_3H	3·7	1·4(T)	6·5	10·0	7·8	6·6
1-Cl-4-OMe-2,3,5-C_6F_3H	3·7	1·3(T)	6·5	10·6	6·8	2·6
1-Cl-2-OMe-3,4,6-C_6F_3H	3·6	2·1(D)	6·4	10·4	9·0	6·7
1-Cl-4-OMe-2,3,6-C_6F_3H	3·5	S	6·2	10·7	7·0	2·4
1-Br-3-OMe-2,4,5-C_6F_3H	—	—	—	9·7	8·0	6·2
1-Br-4-OMe-2,3,5-C_6F_3H	—	—	—	10·2	6·2	2·7
1-Br-2-OMe-3,4,6-C_6F_3H	3·8	2·3(D)	6·7	10·5	8·5	6·6
1-Br-4-OMe-2,3,6-C_6F_3H	3·8	S	6·5	10·3	6·9	2·3
5-I-3-OMe-1,2,4-C_6F_3H	3·6	1·4(T)	6·9	9·3	8·2	5·4
6-I-3-OMe-1,2,4-C_6F_3H	3·6	1·4(T)	6·8	10·2	5·5	2·7
5-I-6-OMe-1,2,4-C_6F_3H	3·8	S	6·6	10·5	7·8	6·2
3-I-6-OMe-1,2,4-C_6F_3H	3·9	2·4(D)	6·5	9·6	6·5	2·3

[a] All footnotes as Table 3.

TABLE 6. TETRAFLUOROHALOGENOBENZENES AND SODIUM METHOXIDE

Compounds	b.p.	Analysis			
		Calc		Found	
		%C	%H	%C	%H
1-Cl-3-OMe-2,5,6-C_6F_3H + 1-Cl-4-OMe-2,3,5-C_6F_3H	163°	42·8	2·0	42·9	2·2
1-Cl-2-OMe-3,4,6-C_6F_3H + 1-Cl-4-OMe-2,4,6-C_6F_3H	160° *a*	42·8	2·0	42·7	1·8
1-Br-3-OMe-2,5,6-C_6F_3H + 1-Br-4-OMe-2,3,5-C_6F_3H	194°	34·9	1·7	35·3	1·8
1-Br-2-OMe-3,4,6-C_6F_3H + 1-Br-4-OMe-2,4,6-C_6F_3H	185° *b*	34·9	1·7	35·1	1·7
5-I-3-OMe-1,2,4-C_6F_3H + 6-I-3-OMe-1,2,4-C_6F_3H	214°	29·2	1·4	29·3	1·5
5-I-6-OMe-1,2,4-C_6F_3H + 3-I-6-OMe-1,2,4-C_6F_3H	216° *c*	29·2	1·4	29·3	1·4

[a] m.p. 24°.
[b] m.p. 60°.
[c] m.p. 88°.

These products were analysed by ^{1}H NMR (Tables 1 and 5) and then distilled (b.ps and elemental analysis of the mixtures in Table 6). Again the products from the 1,2,3,5-tetrafluoro-4-halogenobenzenes were separated by GLC and the structures of separated isomers were further confirmed by ^{1}H and ^{19}F NMR. The 1,2,4-trifluoro-3-halogeno-6-methoxybenzenes were solids and the 1,2,4-trifluoro-5-halogeno-6-methoxybenzenes were liquids (Table 6). The products from the 1,2,3,4-tetrafluoro-5-halogenobenzenes were not separable by GLC and were all liquids.

NMR spectra. The proton spectra were measured on a Varian A60 instrument. ^{19}F spectra of most of the compounds reported in this paper have been measured on a Varian HR 100 instrument at 94·1 Mc/s, and will be reported later; these spectra were all consistent with the structures derived from the proton spectra.

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