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The Reactions of Hexafluoropropylene with Arylamines and the Preparation of *N*-(2,3,3,3-Tetrafluoropropyl)arylamines

Nobuo Ishikawa and Takayoshi Muramatsu
Department of Synthetic Chemistry, Faculty of Engineering, Tokyo Institute of Technology, Meguro-ku, Tokyo

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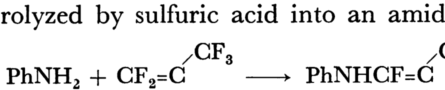
Nucleophilic additions of alkylamines to fluoroolefins are well known.[1] For instance, alkylamines react exothermally with tetrafluoroethylene or chlorotrifluoroethylene to give acetamidines (**2**) *via* imidylfluorides (**1**):[2]

$$RNH_2 + CF_2{=}CFX \longrightarrow R\text{-}N{=}CFCHFX + HF$$

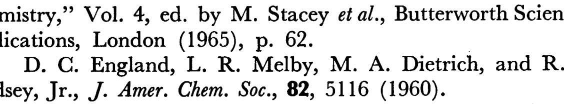
1



$$RNH_2 + \mathbf{1} \longrightarrow R\text{-}N{=}\underset{\substack{|\\ NH\text{-}R}}{C}\text{-}CHFX + HF$$

2

As arylamines are less basic than alkylamines, they are less reactive to fluoroolefins, and little is known about the reactions of arylamines with perfluoroolefins. The early work of Knunyants and his co-workers[3] revealed that aniline and perfluoroisobutene in ether gave the condensed product **3**, which could then be hydrolyzed by sulfuric acid into an amide **4**.



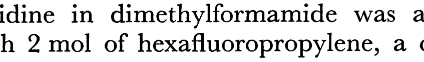
$$PhNH_2 + CF_2{=}C\begin{matrix}\diagup CF_3\\ \diagdown CF_3\end{matrix} \longrightarrow PhNHCF{=}C\begin{matrix}\diagup CF_3\\ \diagdown CF_3\end{matrix} + HF$$

3

$$\mathbf{3} + H_2O \longrightarrow PhNH\text{-}\underset{\substack{\|\\ O}}{C}\text{-}CH\begin{matrix}\diagup CF_3\\ \diagdown CF_3\end{matrix} + HF$$

4

On the other hand, England and his co-workers[2] reported that aniline reacted with 0.25 mol of tetrafluoroethylene at 135°C to give difluoroacetamidine (**5**) in an 85% yield:

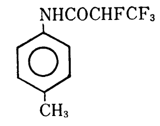


$$PhNH_2 + CF_2{=}CF_2 \longrightarrow PhN{=}\underset{\substack{|\\ NHPh}}{C}\text{-}CHF_2$$

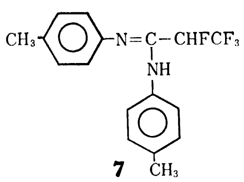
5

We carried out the reactions of aromatic amines with hexafluoropropylene, using dimethylformamide as the solvent. They reacted even at room temperature, and two kinds of products were obtained, depending upon the relative concentration.

As an example, when a dilute solution (about 10%) of *p*-toluidine in dimethylformamide was allowed to react with 2 mol of hexafluoropropylene, a compound with a mp of 93.5—94°C was obtained. From the IR, NMR, and mass spectra, the structure of this compound was found to be *N*-*p*-tolyl-α,β,β,β-tetrafluoropropionamide (**6**). In the IR spectrum, the presence of the –CONH group was shown by strong bands at 1675 (C=O) and 3340 (N-H) cm^{-1}, and in the mass spectrum the parent peak of *m/e* 235 and other reasonable fragment peaks appeared. In the NMR spectra, two kinds of fluorine atoms (CF_3 and CHF) and four kinds of hy-



6



7 CH₃

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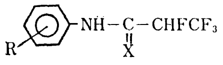
[1] R. D. Chambers and R. H. Mobbs, "Advances in Fluorine Chemistry," Vol. 4, ed. by M. Stacey *et al.*, Butterworth Scientific Publications, London (1965), p. 62.

[2] D. C. England, L. R. Melby, M. A. Dietrich, and R. V. Lindsey, Jr., *J. Amer. Chem. Soc.*, **82**, 5116 (1960).

[3] I. L. Knunyants, L. S. German, and B. L. Dyatkin, *Izv. Akad. Nauk, SSSR., Otd. Khim. Nauk*, **1956**, 1353.

Table 1. Preparations of tetrafluoropropionarylides [A] and tetrafluoropropylarylamines [B]



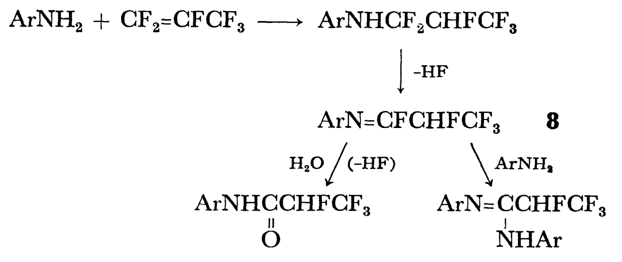
[A] (X=O) [B] (X=H_2)

R	[A] Yield (%)	[A] Mp (°C)	[A] F Anal (%) Obsd	[A] F Anal (%) Calcd	[B] Yield (%)	[B] Bp (°C/mmHg)	[B] F Anal (%) Obsd	[B] F Anal (%) Calcd
H	78.1	83.5—84	36.1	35.9	89.8	97—98/19	36.2	36.7
2-CH_3	44.5	93 —95	32.4	32.3	86.4	114—115/29	30.9	34.4
3-CH_3	75.5	66 —66.5	32.7	32.3	79.9	97—99/11	34.2	34.4
4-CH_3	85.2	93.5—94	32.5	32.3	74.7	108—109/17	34.1	34.4
2,4-$(CH_3)_2$	46.4	110 —110.5	30.2	30.5	74.4	120—121/28	32.4	32.3

drogen atoms (NH, aromatic 4H, CHF and CH_3) appropriately appeared.

When a rather concentrated solution (about 22%) of *p*-toluidine was allowed to react with 1.5 mol of hexafluoropropylene in the same manner, we obtained another compound with a mp of 87—88.5°C. The absorption spectra of this compound were quite different from those of **6**, and we confirmed that this compound is the condensed product of 2 mol of *p*-toluidine and 1 mol of hexafluoropropylene, *i.e.*, *N,N'*-di-*p*-tolyltetrafluoropropionamidine (**7**). The IR spectrum had no C=O band, and the mass spectrum showed an appropriate parent peak (*m*/*e* 324) and fragment peaks. Two kinds of fluorine atoms (CF_3, CHF) and four kinds of hydrogen atoms (Me_2, (aromatic 4H)$_2$, NH, and CHF) were present in the NMR spectra.

The scheme of the above reactions seems to be as follows. The reaction of arylamine and hexafluoropropylene gives the imidylfluoride (**8**) first. When the reaction mixture is then treated with water, this **8** is hydrolyzed into the propionamide (**9**), but if an excess arylamine is present in the reaction system, **8** reacts with it further to give the propionamidine (**10**):



8

9 **10**

In addition to *p*-toluidine, we reacted aniline, *o*- and *m*-toluidines, and 2,4-xylidine with hexafluoropropylene at a low arylamine concentration; in each case, we could obtain the corresponding tetrafluoropropionarylide in a good yield (Table 1).

Because of the strong electronegativity of the fluorine atom, these tetrafluoropropionarylides were not stable to alkali, and when heated in a dilute aqueous sodium hydroxide solution they were readily hydrolyzed to arylamine and tetrafluoropropionic acid. Therefore, we carried out the reduction of the carbonyl groups of these amides with lithium aluminum hydride and thus obtained stable *N*-(tetrafluoropropyl)arylamines. The physical properties of these amines are listed in Table 1.

Experimental

N-p-*Tolyl-α,β,β,β-tetrafluoropropionamide (6).* A solution of 2.14 g (0.02 mol) of *p*-toluidine in 20 m*l* of dimethylformamide was put into an autoclave (100 m*l*) and cooled to about −40°C. 0.04 Mol of liquefied perfluoropropylene was then added to the autoclave, and the temperature of the reaction vessel was allowed to rise to room temperature (20°C), whereupon the mixture was agitated magnetically at this temperature for six hours. Then the reaction mixture was thrown into water; after it had been stirred for a while, an oily matter solidified and a pale yellow crystalline mass separated out. This was filtered off, washed, and dried to give 4.04 g of (85.2%) the crude product. After recrystallization from dilute methanol, colorless crystals with a mp of 93.5—94°C were obtained. IR: 3340 (N–H), 1675 (C=O), 1145, 1188 (C–F) cm^{-1}. NMR (in $CDCl_3$): ^1H τ 7.72 (CH_3, s), 4.88 (CHF, dq), 2.47—3.07 (arom-H, dd), 1.72 (NH, br); ^{19}F δ −3.0 (CF_3, dd), +122.8 (CHF, m) from external CF_3CO_2H. MS: *m*/*e* 91 ($C_6H_5CH_2$), 106 ($CH_3C_6H_4NH$), 134 ($CH_3C_6H_4NHCO$), 235 ($C_{10}H_9ONF_4$).

The reactions with other arylamines were run similarly, and the products (Table 1) gave similar IR and NMR spectra.

N,N'-*Di*-p-*tolyl-α,β,β,β-tetrafluoropropionamidine (7).* A solution of 4.28 g (0.04 mol) of *p*-toluidine in 15 m*l* of dimethylformamide was allowed to react with 0.06 mol of hexafluoropropylene in the same manner as in the above reaction. After five hours, the reaction mixture was treated with water; 4.72 g (72.8%) of yellow crystals were thus obtained. This crude product was dissolved in benzene, and the solution was chromatographed on an activated alumina column. The yellow band was eluted with benzene, the solvent was evaporated, and the residue was recrystallized from dilute methanol, thus giving colorless crystals with a mp of 87—88.5°C

Found: F 23.1%, Calcd for $C_{17}H_{16}F_4N_2$: F 23.4%. IR: 3240 (N–H), 1133, 1183 (C–F) cm^{-1}. NMR (in $CDCl_3$): ^1H τ 7.78 (CH_3, s), 4.42 (CHF, m), 2.85—3.70 (arom-H, dd), 2.62 (NH, br); ^{19}F δ −3.3 (CF_3, dd), +124.4 (CHF, m) from external CF_3CO_2H. MS: *m*/*e* 65 (C_5H_5), 91 ($C_6H_5CH_2$), 107 (C_7H_7NH+H), 218 ($C_7H_7N{=}C{-}CHFCF_3$), 324 ($C_{17}H_{16}N_2F_4$).

N-*(2,3,3,3-Tetrafluoropropyl)*-p-*tolylamine.* A solution of 1.52 g (0.04 mol) of lithium aluminum hydride in 50 m*l* of diethyl ether was cooled in an ice-salt bath and then a solution of 4.70 g (0.02 mol) of **6** in 15 m*l* of diethyl ether was stirred mechanically in at 0—5°C. After the addition, stirring was continued for three hours at room temperature; the solution was then allowed to stand for one day. Into the reaction mixture a small amount of ethyl acetate and water was then added cautiously in order to decompose the excess lithium aluminum hydride; the ether layer was evaporated, and then the residue was distilled out in a vacuum. A colorless liquid with a bp of 108—109°C/17 mmHg which weighed 3.30 g (74.7%) was thus obtained. IR: 3440 (N-H), 1150, 1186 (C-F)cm^{-1}. NMR: ^{1}H τ 7.89 (CH_3, s), 6.98 (NH, br), 6.59 (CH_2, m), 5.55 (CHF, m), 3.02—3.90 (arom-H, m); ^{19}F δ +0.01 (CF_3, dd), +125.8 (CHF, m) from external CF_3CO_2H.

The other tetrafluoropropionarylamides were also reduced in the same manner (Table 1): their products gave similar IR and NMR spectra.