

Journal of Fluorine Chemistry 103 (2000) 159-161



www.elsevier.com/locate/jfluchem

A simple route to hexamethylguanidinium fluoride

A.A. Kolomeitsev^{a,*}, G. Bissky^b, P. Kirsch^c, G.-V. Röschenthaler^b

^aInstitute of Organic Chemistry, Ukrainian National Academy of Sciences, Murmanskaya 6, 253660 Kiev-94, Ukraine ^bInstitut für Anorganische & Physikalische Chemie, Universität Bremen, Leobener Strasse, D-28334 Bremen, Germany ^cMERCK KGaA, Liquid Crystals Division, Frankfurter Strasse 250, Darmstadt D-64293, Germany

Received 20 September 1999; accepted 16 November 1999

Dedicated to Prof. Manfred Meisel, on the occasion of his 60th birthday

Abstract

Tetramethylchloroformamidinium chloride reacts with 2 mol equivalents of tetramethylammonium fluoride to give bis(dimethylamino)difluoromethane (1). The treating of 1 with dimethylaminotrimethylsilane in acetonitrile yields quantitatively hexamethylguanidinium fluoride (2). Reaction of 2 with (trifluoromethyl)trimethylsilane provides an easy access to 1,1,1-trifluoro-2,2,2-tris(dimethylamino)ethane (4). \bigcirc 2000 Elsevier Science S.A. All rights reserved.

Keywords: 'Naked' fluoride ion; Hexamethylguanidinium fluoride

1. Introduction

There has been much interest in recent years in the generation of highly nucleophilic sources of soluble fluoride ion for application in organic and inorganic synthesis. One of the most useful approaches for 'naked' fluoride has proved to be anhydrous tetramethylammonium fluoride or the salt $TDAE^{2+}2F^{-}$ [TDAE = tetrakis(dimethylamino)ethylene], recently synthesized from elemental fluorine, which could be quite easily prepared in hydrogen difluoride free form [1-5]. Due to elimination reactions, the complete drying of quaternary ammonium fluorides has been found to be possible only for the simplest representative, tetramethylammonium fluoride which lacks β -hydrogen atoms. The main advantages of TMAF are the high thermal and chemical stability of the tetramethylammonium cation and the extreme high nucleophilicity of the 'naked' fluoride ion. Anhydrous TMAF [1,2,4] is a very strong base, deprotonating CH₃CN at ambient temperature (its basicity can be reduced by application of azeotropically dried TMAF, which is also a very good nucleophile, where the remaining water reduces its basicity significantly) [3]. Another approach includes the synthesis of hypervalent fluorosilicon or tin onium derivatives showing excellent fluorinating power and

E-mail address: alex@chemie.uni-bremen.de (A.A. Kolomeitsev).

being a source of 'naked' fluoride as well [6–10]. Among the fluoride ion sources of the last type the most important is TASF [6]. The TAS counterion is remarkably stabilizing for many fluorinated anionic species, e.g. perfluoroalkyl, perfluoroalkyloxy anions [11]. Hexamethylguanidinium (HMG) 1,1,1,3,3,3-hexafluoro-2-(trifluoromethyl)-2-propanide, $[C(NMe_2)_3]^+[C(CF_3)_3]^-$, a stable solid, was prepared from HMG^+F^- , HF_2^- and perfluoroisobutene [12]. The chemistry of hexamethylguanidinium fluoride (HMGF) (2) has not been developed, apparently, because of its difficult access [13]. The difficulties in growing of single crystals of the phosphoranides [14] $NMe_4^+[P(CF_3)_3F]^-$ and $NMe_4^+[P(CF_3)_4]^-$ prompted us to search for counter ions other than Me₄N⁺, e.g. HMG⁺. For this purpose and also for stabilizing perfluoroalkyl or perfluoroalkyloxy anions the lipophilic and robust HMG⁺ cation, where the positive charge is distributed over three nitrogen atoms should be superior to TMAF. It seems to be very attractive and useful for application in basic and applied organofluorine chemistry. Hence, we decided to find a simple preparative approach for HMGF excluding or minimizing the content of hydrogen difluoride impurities.

2. Results and discussion

The interaction of bis(dimethylamino)difluoromethane with dimethylaminotrimethylsilane in different solvents surprisingly gave HMGF (2), in contrast to the reaction

^{*}Corresponding author. Present address: Institut für Anorganische & Physikalische Chemie, Universität Bremen, Leobener Strasse, D-28334 Bremen, Germany. Fax: +49-421-218-42-67.

^{0022-1139/00/\$ –} see front matter 0 2000 Elsevier Science S.A. All rights reserved. PII: S 0 0 2 2 - 1 1 3 9 (99) 0 0 3 0 7 - 3

of dimethylaminotrimethylsilane with sulfur tetrafluoride [6], where a hypervalent trimethyldifluorosilicate anion was found. Probably, the C-F bond in 2 has a partial covalent character and the $(Me_2N)_3C^+$ cation is more electrophilic than the competing Me₃SiF. The reaction proceeds very slowly (over 2 or 3 weeks) in pentane, diethyl ether or monoglyme. A small addition of CH₃CN accelerated the reaction. In order to optimize the synthesis, a low temperature ¹⁹F NMR study has been carried out. A solution of dimethylaminotrimethylsilane and bis(dimethylamino)difluoromethane in CH₃CN in a sealed NMR tube was investigated at -45 to 0°C. The reaction is rather slow at -45°C, but at 0°C the resonance of bis(dimethylamino)difluoromethane at $\delta = -97$ disappeared and only one new ¹⁹F NMR signal at $\delta = -63.1$ due to fluoride 2 was observed within 2.5 h besides the resonances for Me₃SiF ($\delta_{\rm F} = 157$). The deprotonation of CH₃CN with **2** at 0° C is very slow. However, to prevent the formation of $[C(NMe_2)_3]^+HF_2^$ the reaction mixture has to be worked up at -30° C (see Section 3, Scheme 1)

The authors of the previous synthesis [13] observed by ¹⁹F NMR that the solution of **2** in DMF at ambient temperature showed a 50% HF₂⁻ impurity. Surprisingly, in our case no significant $\mathrm{HF_2}^-$ concentration was detected. A saturated solution of 2 in CH₃CN formed only 5.5% mol of HF_2^- within 24 h at 20°C. We have also tried to prepare 2 in accordance with the synthesis of anhydrous TMAF [4]. The metathesis of $[C(NMe_2)_3]^+BF_4^-$ salt with a solution of oven dried KF in anhydrous methanol (in isopropanol KF is sparingly soluble) proceeds quantitatively to afford $[C(NMe_2)_3]^+F^ [\delta_F(CH_3OH) = -147.9$ (s), $\delta_F(H_2O) =$ -119 (s). But after removing methanol (20–130°C, 0.01 mbar) $[C(NMe_2)_3]^+HF_2^-$ was obtained $(\delta_H = 2.83)$ (s); $\delta_{\rm F} = -147.7$ (d), $J_{\rm HF} = 120.7$ Hz). Just recently $(HMG^+)_2SiF_6^{2-}$ synthesis was published, but there was no indication on the generation and characterization of HMGF in this paper [15].

The synthesis of $(Me_2N)_2CF_2$ (1), previously obtained by fluorination of tetramethylcarbamide using COF₂ or from tetramethylthiocarbamide and SF₄ [16], has also been improved, namely via the straightforward fluorination of $[(Me_2N)_2CC1]^+Cl^-$ using anhydrous Me₄NF. When this paper had been accepted for publication, a patent describing a simple high yield Halex synthesis of bis(dialkylamino)difluoromethanes was published [17] (Scheme 2 and Scheme 3).







Interestingly, compound **2** and (trifluoromethyl)trimethylsilane in monoglyme at -80° C gave the stable hypervalent silicate (Me₂N)₃C⁺[(CF₃)₂SiMe₃]⁻ (**3**) as the sole product, stable in monoglyme solution to -60° C. Upon warming to -50° C, compound **3** yielded very slowly (Me₂N)₃CCF₃ (**4**) and Me₃SiCF₃ [18]¹. At -30° C the reaction became fast and was complete in 1 h. Most conveniently 1,1,1-trifluoro-2,2,2-tris(dimethylamino)ethane, **4** can be prepared by reacting **2** with 2–3 equivalents of Me₃SiCF₃ in diethyl ether at -50° C followed by warming up the reaction mixture to ambient temperature [19].

The results of the X-ray structural investigations of compounds **2** and **4**, the use of **4** for new carbon–carbon bond formation reactions and the interaction of dimethylaminotrimethylsilane with dimethylamine addition products to F-alkenes will be published in due course.

In summary, the reaction of bis(dimethylamino)difluoromethane with dimethylaminotrimethylsilane provides a rapid and facile access to hexamethylguanidinium fluoride soluble in organic solvents (e.g. CH₃CN, DMSO, DMF, monoglyme, THF) without hydrogen difluoride impurity. In the light of the present availability of $(R_2N)_2CF_2$ and the proposed simple synthetic protocol of the HMGF synthesis, the salts of the general formula $(R_2N)_3C^+F^-$ have become easily available for investigation in basic organic and industrial organofluorine chemistry.

3. Experimental

Mass-spectra (FAB) were recorded on a Finnigan MAT 8222 spectrometer using a glycerol matrix. NMR spectra were obtained on a Bruker DPX-200 spectrometer operating at 200.13 MHz for ¹H, 50.32 MHz for ¹³C (internal standard TMS), 188.31 MHz for ¹⁹F (internal standard CFCl₃). CH₃CN was distilled from phosphorus pentoxide and then stored over calcium hydride. All reactions and manipulations were conducted under an atmosphere of dry nitrogen.

¹10-(Trifluoromethyl)-1,4,7-triazatricyclo[5,2,1,0^{4,10}]decane has been synthesized.

3.1. Bis(dimethylamino)difluoromethane (1)

To a stirred solution of 17.1 g (100 mmol) tetramethylchloroformamidinium chloride in CH₂Cl₂ (50 ml) held at 0°C, 23.3 g (250 mmol) tetramethylammonium fluoride was added over 5 min. The cold mixture was stirred for an additional 5 h, the precipitate filtered off, and washed twice with 25 ml pentane. The resulting solution was distilled using a 30 cm Vigreux column. Yield 13.1 g (95%). Purity 96–97% (¹H NMR); bp 99–100°C. ¹⁹F NMR: δ = 97.0 (s) [16].

3.2. Hexamethylguanidinium fluoride (2)

A mixture of 3.4 g (29 mmol) dimethylaminotrimethylsilane, 2.0 g (14.5 mmol) bis(dimethyl-amino)difluoromethane in acetonitrile (10 ml) was stirred for 2.5 h at 0°C. After cooling to -30°C the reaction mixture was diluted with diethyl ether (30 ml), which was added over 5 min, and the precipitated product (salt) was filtered under nitrogen and washed with diethyl ether (10 ml) to yield 1.9 g (95%) hexamethylguanidinium fluoride, mp 166–167°C. ¹⁹F NMR: $\delta = -63.1$ (s) (CD₃CN, -30°C); ¹H NMR: $\delta = 2.95$ (s) [13]. The same reaction proceeded in 81% yield in monoglyme (20°C, 2 weeks) or in monoglyme/ CH₃CN (20 : 1) (-20°C, 24 h).

3.3. 1,1,1-Trifluoro-2,2,2-tris(dimethylamino)-ethane (4)

Diethyl ether (10 ml) and 1.00 g (5.49 mmol) guanidinium fluoride were held at -50° C, 2.1 g (14.79 mmol). Me₃SiCF₃ was added and the mixture stirred at -50° C for 1 h. Then the temperature was slowly raised to 20°C and the solvent pumped off in vacuo. Yield: 1.12 g (96%); bp 166-169°C (dec.); FAB positive(glycerol) m/z (%) 198 $(M^+ - Me,$ 12), 169 $(M^+ - NMe_2,$ 100), 144 $([C(NMe_2)_3]^+, 42), 129 (M^+ - Me - CF_3, 11)$ and other fragments; FAB negative (glycerol) 69 (CF_3^- , 32) and other fragments. ¹H NMR: $\delta = 2.33$ (⁵ $J_{\text{HF}} = 1.23$ Hz); ¹⁹F NMR: $\delta = -62.5$; ¹³C NMR $\delta_{\rm C} = 127.35$ (CF₃, ¹ $J_{\rm CF} = 305.6$ Hz),

92.24 (C(NMe₂)₃,
$${}^{2}J_{CF} = 23.7$$
 Hz), 39.36 (CH₃, ${}^{4}J_{CF} = 2.3$ Hz).

Acknowledgements

A.A.K. is grateful to the Deutsche Forschungsgemeinschaft for financial support.

References

- [1] K.O. Christe, W.W. Wilson, R.D. Wilson, R. Bau, J. Feng, J. Am. Chem. Soc. 112 (1990) 7619.
- [2] K. Seppelt, Angew. Chem. 104 (1992) 299.
- [3] D.J. Adams, J.H. Clark, Chem. Soc. Rev. 28 (1999) 225.
- [4] A.A. Kolomeitsev, F.U. Seifert, G.-V. Röschenthaler, J. Fluorine Chem. 71 (1995) 47.
- [5] R.D. Chambers, W.K. Gray, G. Sandford, J.F.S. Vaughan, J. Fluorine Chem. 94 (1999) 213.
- [6] W.J. Middleton, Patent US N3 940 402, 1976.
- [7] M. Gingras, Tetrahedron Lett. 32 (1991) 7381.
- [8] Y. Hatanaka, K. Goda, Y. Okahara, T. Hiyama, Tetrahedron 50 (1994) 8301.
- [9] P.S. Pilcher, H.L. Ammon, P. DeShong, J. Am. Chem. Soc. 117 (1995) 5166.
- [10] M.-R. Brescia, P. DeShong, J. Org. Chem. 63 (1998) 3156.
- [11] B.E. Smart, W.J. Middleton, W.B. Farnham, J. Am. Chem. Soc. 108 (1986) 4905.
- [12] N.I. Delyagina, S.M. Igumnov, V.F. Snegirev, I.L. Knunyants, Bull. Acad. Sci. USSR Div. Chem. Sci. 30 (1981) 1836.
- [13] S.M. Igumnov, N.I. Delyagina, I.L. Knunyants, Bull. Acad. Sci USSR Div. Chem. Sci. 35 (1986) 1193.
- [14] A.A. Kolomeitsev, M. Görg, E. Lork, U. Dieckbreder, G.-V. Röschenthaler, Phosphorus, Sulfur, Silicon 109/110 (1996) 597.
- [15] X. Zhang, R. Bau, J.A. Sheehy, K.O. Christe, J. Fluorine Chem. 98 (1999) 121.
- [16] F.S. Fawcett, C.W. Tullock, D.D. Coffman, J. Am. Chem. Soc. 84 (1962) 4275.
- [17] H. Sonoda, K. Okada, K. Goto, K. Fukumura, J. Naruse, H. Hayashi, T. Nagata, A. Takanashi, Eur. Pat. Appl. EP 0949226, 1999.
- [18] G.M.J. Slusarczuk, M.M. Joullié, Chem. Commun. (1970) 469.
- [19] A. Kolomeitsev, G. Bissky, E. Lork, V. Movchun, E. Rusanov, P. Kirsch, G.-V. Röschenthaler, J. Chem. Soc. Chem. Commun. (1999) 1017.