Synthesis of 3,3,4,4-tetrafluoro-4-iodobutylamine, a bifunctional reagent for ionic and free-radical reactions

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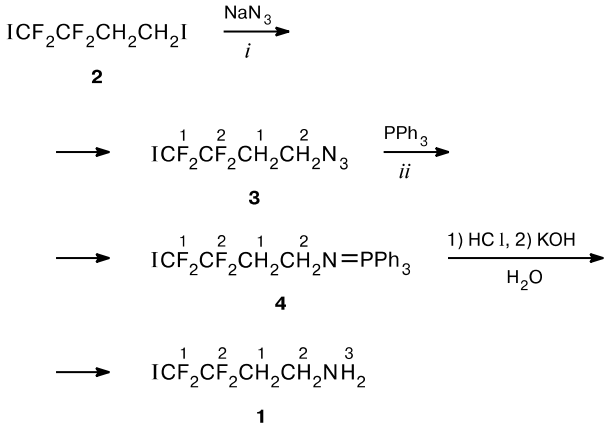
1,1,2,2-Tetrafluoro-1,4-diiodobutane reacts with NaN_3 under phase-transfer catalysis conditions to give 3,3,4,4-tetrafluoro-4-iodobutyl azide. The reduction of the azide with triphenylphosphine followed by hydrolysis of intermediate iminophosphorane affords 3,3,4,4-tetrafluoro-4-iodobutylamine.

Key words: 3,3,4,4-tetrafluoro-4-iodobutyl azide, 3,3,4,4-tetrafluoro-4-iodobutylamine.

2-Perfluoroalkylethylamines are important intermediate products in organic and organofluorine chemistry (*e.g.*, see Refs 1—3). In the present work, we report on the synthesis of earlier unknown 3,3,4,4-tetrafluoro-4-iodobutylamine (**1**), an unusual bifunctional compound combining the properties of the nucleophilic amino group and the perfluoroiodoalkyl group tending toward free-radical reactions.[4]

We used a known approach involving transformations of 2-perfluoroalkylethyl iodides into 2-perfluoroalkylethyl azides followed by the reduction to the corresponding amines. In our case, this reaction sequence proceeded from 1,4-diiodobutane **2** to iodo amine **1** through intermediate iodo azide **3** (Scheme 1).

Scheme 1



i. $BnN^+Et_3Cl^-$, H_2O; *ii.* Benzene.

† Deceased.

Azide **3** was obtained in 94% yield in a two-phase system with benzyl(triethyl)ammonium chloride (TEBA) as a phase-transfer catalyst (PTC). TEBA proved to be as efficient as the phase-transfer catalysts used earlier.[5,6] The selective replacement of the iodine atom in the group CH_2I was confirmed by NMR and mass spectra. In the ^1H NMR spectrum of iodo azide **3**, the chemical shift of the terminal CH_2 group is appreciably different from that for diiodide **2**, while the ^{19}F NMR spectrum remains virtually unchanged (for the NMR spectra of diiodide **2**, see Ref. 7). The mass spectrum of compound **3** shows sufficiently intense peaks of the ions CF_2I^+ and $C_2F_4I^+$ and no analogous peaks due to the alkyliodide ions.

In order to reduce azide **3**, we transformed it into iminophosphorane **4** under the action of triphenylphosphine. Hydrolysis of compound **4** with HCl gave amine hydrochloride **1** · HCl. Free iodoamine **1** was isolated in 94% yield (with respect to azide **3**).[5,8] Thus, the net yield of iodobutylamine **1** from diiodobutane **2** exceeded 88%.

Experimental

^1H and ^{19}F (with CF_3COOH as the external standard) NMR spectra were recorded on a Bruker WP-200SY spectrometer. IR spectra were recorded on a UR-20 spectrometer. Mass spectra were measured on a VG 7070E mass spectrometer (EI, 70 eV).

Tetrafluorodiiodobutane **2** was prepared in 82% yield according to a patented[9] procedure (the conversion of tetrafluoro-1,2-diiodoethane was 94%). Commercial chemicals (NaN_3, TEBA, and PPh_3) were used as purchased. Benzene was purified and dried according to a standard procedure.

3,3,4,4-Tetrafluoro-4-iodobutyl azide (3). A mixture of diiodide **2** (99.03 g, 0.2593 mol), NaN_3 (36.10 g, 0.5553 mol), and TEBA (3.05 g, 0.0134 mol) was stirred in water (100 mL) and refluxed for 12 h. The organofluorine phase was separated; the aqueous phase was extracted with CH_2Cl_2. The combined or-

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ganic phases were washed with water, dried over $MgSO_4$, and concentrated. Distillation of the residue gave butyl azide **3** (72.30 g, 93.9%) as a colorless liquid, b.p. 46—48 °C (4 Torr), 99.7% purity (NMR, GLC). Found (%): C, 16.3; H, 1.52; F, 25.5; N, 14.3. $C_4H_4F_4IN_3$. Calculated (%): C, 16.2; H, 1.36; F, 25.6; N, 14.1. IR, ν/cm^{-1}: 2150 vs (N_3). ^{1}H NMR ($CDCl_3$), δ: 2.38 (br.tt, 2 H, H(1), $^3J_{H(1),F(2)}$ = 17.8 Hz, $^3J_{H(1),H(2)}$ = 7.3 Hz); 3.60 (t, 2 H, H(2), $^3J_{H(2),H(1)}$ = 7.3 Hz). ^{19}F NMR ($CDCl_3$), δ: −30.0 (tt, 2 F, F(2), $^3J_{F(2),H(1)}$ = 17.8 Hz, $^3J_{F(2),F(1)}$ = 5.0 Hz); 17.2 (br.t, 2 F, F(1), $^3J_{F(1),F(2)}$ = 5.1 Hz). MS, *m/z* (I_{rel} (%)): 297 $[M]^+$ (0.6); 268 $[M - HN_2]^+$ (2.0); 254 $[M - HN_3]^+$ (0.8); 227 $[C_2F_4I]^+$ (1.7); 177 $[CF_2I]^+$ (40.6); 127 $[I]^+$ (35.7); 122 $[C_4H_3F_3N]^+$ (32.7); 95 $[C_3H_2F_3$ and/or $C_2F_3N]^+$ (38.0); 92 $[C_3H_4F_2N]^+$ (27.2); 78 $[C_3H_4F_2$ and/or $C_2H_2F_2N]^+$ (100); 69 $[C_2H_3N_3]^+$ (38.0); 64 $[C_2H_2F_2]^+$ (43.6); 51 $[CF_2H]^+$ (20.5); 42 $[C_2H_4N]^+$ (76.0).

***N*-(3,3,4,4-tetrafluoro-4-iodobutyl)iminotriphenylphosphorane (4).** A solution of PPh_3 (69.30 g, 0.2642 mol) in benzene (200 mL) was added to a solution of azide **3** (71.13 g, 0.2395 mol) in dry benzene (100 mL). The addition rate was such as to prevent the solvent from boiling (~25 min). The reaction mixture was cooled to room temperature, while stirring it for 30—40 min. The solvent was removed on a rotary evaporator; the residue was dried at 60—70 °C (1 Torr) to a constant weight. The yield of iminophosphorane **4** was 133.4 g (~100%). Compound **4** contained an impurity of PPh_3 (TLC, NMR). ^{1}H NMR (CH_2Cl_2), δ: 2.13 (br.tt, 2 H, H(1), $^3J_{H(1),F(2)}$ = 19.0 Hz, $^3J_{H(1),H(2)}$ = = 8.1 Hz); 3.19 (br.dt, 2 H, H(2), $^3J_{H(2),P}$ = 17.6 Hz, $^3J_{H(2),H(1)}$ = = 8.1 Hz); 7.1—7.5 (m, 16 H, Ph (with an impurity of PPh_3)). ^{19}F NMR (CH_2Cl_2), δ: −31.2 (tt, 2 F, F(2), $^3J_{F(2),H(1)}$ = 19.0 Hz, $^3J_{F(2),F(1)}$ = 4.6 Hz); 15.9 (br.t, 2 F, F(1), $^3J_{F(1),F(2)}$ = 4.6 Hz).

Imine **4** (137.5 g, ~100%) was obtained in a similar way from azide **3** (72.30 g, 0.2434 mol) and PPh_3 (71.50 g, 0.2726 mol) in benzene (300 mL). The target product also contained an impurity of PPh_3.

3,3,4,4-Tetrafluoro-4-iodobutylamine (1). Crude imine **4** was stirred in batches (66.4, 66.8, and 2×68.5 g) for 3 h and refluxed with 10% HCl (200 mL per batch). The reaction mixture was cooled and stirred with water (200 mL) for 1 h until a well-filterable precipitate formed. The precipitate of Ph_3PO containing PPh_3 (TLC) was filtered off and washed with 5% HCl. The combined filtrates were concentrated on a rotary evaporator; the residue was dried over KOH at 65—70 °C (1 Torr) to a constant weight. The yield of amine hydrochloride **1**·HCl was 147.4 g (>99%). The hydrochloride was neutralized with a solution of KOH (71.4 g) in water (240 mL) and Et_2O (60 mL). The organic phase was separated; the aqueous phase was extracted with ether. The combined extracts were dried over KOH and concentrated. Distillation of the residue gave tetrafluoroiodobutylamine **1** (122.95 g, 94.0%) as a colorless liquid solidifying into a white crystalline solid, b.p. 68 °C (16 Torr), m.p. 34—36 °C (in a sealed capillary), 99.7% purity (NMR, GLC). Found (%): C, 17.3; H, 2.25; F, 27.6; N, 5.13. $C_4H_6F_4IN$. Calculated (%): C, 17.3; H, 2.23; F, 28.0; N, 5.17. ^{1}H NMR ($CDCl_3$), δ: 1.28 (br.s, 2 H, H(3)); 2.22 (br.tt, 2 H, H(1), $^3J_{H(1),F(2)}$ = 18.5 Hz, $^3J_{H(1),H(2)}$ = = 7.1 Hz); 3.16 (t, 2 H, H(2), $^3J_{H(2),H(1)}$ = 7.1 Hz). ^{19}F NMR ($CDCl_3$), δ: −29.5 (tt, 2 F, F(2), $^3J_{F(2),H(1)}$ = 18.5 Hz, $^3J_{F(2),F(1)}$ = = 4.8 Hz); 17.4 (br.t, 2 F, F(1), $^3J_{F(1),F(2)}$ = 4.9 Hz). MS, *m/z* (I_{rel} (%)): 271 $[M]^+$ (0.4); 270 $[M - H]^+$ (0.3); 177 $[CF_2I]^+$ (0.6); 127 $[I]^+$ (1.5); 77 $[C_3H_3F_2]^+$ (1.0); 64 $[C_2H_2F_2]^+$ (0.8); 43 $[C_2H_5N]^+$ (4.7); 42 $[C_2H_4N]^+$ (1.3); 30 $[CH_4N]^+$ (100).

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