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SYNTHETIC UTILITY OF 3-(PERFLUORO-1,1-DIMETHYLBUTYL)-1-PROPENE. PART II. SYNTHESIS OF NEW 2-HYDROXY-3-(PERFLUOROALKYL)PROPYL-AMINES

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SUMMARY

A number of 2-hydroxy-3-(perfluoroalkyl)propylamines of general formula $CF_3CF_2CF_2C(CF_3)_2CH_2CH(OH)CH_2NR'R''$ were obtained in high yields by treatment of the corresponding 3-(perfluoroalkyl)-1,2-epoxypropane with ammonia and with aliphatic and cycloaliphatic amines. The new fluorinated hydroxyamines have been characterised by elemental analyses, boiling points, and by the high resolution ^1H NMR spectral data.

INTRODUCTION

Long-chain aliphatic amines are valuable products since, in the form of quaternary ammonium salts, they constitute the largest group of cationic surface active agents. Many of these compounds combine both surface activity and remarkable bactericidal or fungicidal power and therefore, they are widely used as germicides, fungicides and disinfectants [1,2]. Amines containing perfluorinated aliphatic chain are important intermediates for the synthesis of fluorinated surfactants of unique properties; for example, the amine oxide of the formula $C_3F_7O(CF_2)_3C(O)NH(CH_2)_3N(O)(CH_3)_2$ is an excellent emulsifier which has been used to prepare stable aqueous microemulsions of perfluorocarbons [3]. The amine-type fluorosurfactants are usually

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synthesized by condensing perfluoroalkanocarboxylic acid halides or esters with substrates containing terminal tertiary amino groups [4]. Another type of compounds, viz., 2-hydroxy-2-(perfluoroalkyl)ethylamines, $R_FCH(OH)CH_2NR'R''$, have been obtained by aminolysis of perfluoroalkyl ethylene oxides, $R_F\overleftarrow{CHCH_2}O$ [5]. These amines were used to prepare quaternary ammonium salts, betaines, and amine oxides showing particularly low surface tension in water solutions [6].

In the preceeding paper [7] we reported a new approach to perfluoroalkyl compounds suitable as intermediates for fluorosurfactants using readily available 3-(perfluoro-1,1-dimethylbutyl)-1-propene (**1**) as the starting material; the high yield, two-step conversion of alkene **1** to 3-(perfluoro-1,1-dimethylbutyl)-1,2-epoxypropane (**2**) has been developed.

1 **2**

This paper describes reactions of epoxide **2** with a variety of amines leading to the new 2-hydroxy-3-(perfluoro-1,1-dimethylbutyl)-propylamines.

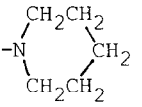
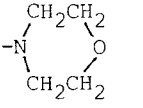
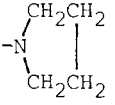
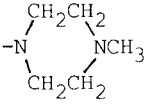
RESULTS AND DISCUSSION

Epoxide **2** when treated with an excess of ammonia or aliphatic or cycloaliphatic amines undergoes the oxirane ring opening to give 2-hydroxy-3-(perfluoro-1,1-dimethylbutyl)propylamines (**3** - **14**). Epoxide **2** is somewhat less reactive towards amines as compared to perfluoroalkylethylene oxides reported by Cambon et al., which reacted at ambient temperature [5], but the reactions proceeded smoothly at the reflux temperatures (76 - 138°C). The reaction conditions and yields are given in Table 1.

Lower boiling amines, like tert-butylamine (b.p. 46°C), failed to react with epoxide **2** at the amine reflux temperature, therefore, in this case and in cases of other volatile amines the reaction tempera-

ture was increased by addition of sufficient amount of ethyl alcohol. Ammonia, methylamine, and dimethylamine were used as ethanolic solutions saturated at ambient temperature and the reactions were conducted in a sealed glass ampoule. Ethanol was also used as a solvent for the reaction with high boiling and viscous diethanolamine; all other reactions were carried out simply by refluxing **2** with an excess of the amine.

3 - 14

Compound	-NR'R"	Compound	-NR'R"
3	$-NH_2$	**12**	
4	$-NHCH_3$		
5	$-NHCH_2CH_3$		
6	$-NHC(CH_3)_3$		
7	$-NH(CH_2)_2N(CH_3)_2$		
8	$-NH(CH_2)_3N(CH_3)_2$	**13**	
9	$-N(CH_3)_2$		
10	$-N(CH_2CH_2OH)_2$		
11		**14**	

2-Hydroxy-3-(perfluoro-1,1-dimethylbutyl)propylamines (**3** - **13**) are high boiling (Table 2) colourless substances of consistency varying from slightly viscous liquids to glassy syrups. The exception is fine crystalline (m.p. 103°C) compound **14** prepared from N-methylpiperazine. Also, compound **6** on standing for several weeks slowly undergoes conversion to a low melting crystalline substance.

The molecular compositions of compounds **3** - **14** were obtained from elemental analyses (Table 2). The structures of the non-fluorinated parts of these compounds were confirmed by the high resolution ^1H NMR

TABLE 1

Reactions of epoxide **2** with amines

Amine HNR'R"	Reaction conditions				Product	
	Amine/**2** mol.ratio	Solvent	Temp. °C	Time h	no.	Yield (%)[a]
NH_3	18	ethanol[b]	80[c]	48	**3**	85
H_2NCH_3	21	ethanol[d]	90[c]	8	**4**	93
$H_2NCH_2CH_3$	15	ethanol[d]	reflux	5	**5**	87
$H_2NC(CH_3)_3$	11	none	reflux	5	no reaction	
	11	ethanol	reflux	5	**6**	79
$H_2N(CH_2)_2N(CH_3)_2$	4	none	reflux	2	**7**	87
$H_2N(CH_2)_3N(CH_3)_2$	3	none	reflux	5	**8**	90
$HN(CH_3)_2$	12	ethanol[b]	80[c]	24	**9**	75
$HN(CH_2CH_2OH)_2$	2	ethanol	reflux	5	**10**	75
pyrrolidine	5	none	reflux	5	**11**	93
piperidine	4	none	reflux	5	**12**	91
morpholine	5	none	reflux	5	**13**	93
N-methylpiperazine	4	none	reflux	3	**14**	92

[a] Isolated yields in mole % of **2**.

[b] Ethanolic amine solution saturated at ambient temperature.

[c] The reaction was carried out in a sealed glass ampoule.

[d] Commercial 33% amine in ethanol.

TABLE 2

Physical properties and analyses of compounds **3** - **14**

$$CF_3CF_2CF_2C(CF_3)_2CH_2\underset{\underset{OH}{|}}{C}HCH_2NR'R''$$

Compnd no.	B.P. °C(Torr)	M.P. °C	Analysis: found(calculated), % C	H	F	N
3	107(20)		28.0(27.5)	2.0(2.1)	62.8(62.8)	3.6(3.6)
4	102(20)		29.5(29.5)	2.4(2.5)	60.7(60.7)	3.4(3.4)
5	112(20)		31.4(31.4)	2.8(2.9)	58.7(58.6)	3.3(3.3)
6	116(18)	41-42*	34.8(34.8)	3.6(3.6)	54.9(55.0)	3.2(3.1)
7	78(0.1)		33.8(33.6)	3.6(3.7)	53.3(53.2)	6.0(6.0)
8	84(0.1)		35.1(35.2)	4.1(4.0)	51.5(51.6)	5.9(5.9)
9	58(0.6)		31.3(31.4)	2.8(2.9)	58.5(58.6)	3.2(3.3)
10	150(0.4)		32.4(34.4)	3.2(3.4)	51.3(51.3)	2.8(2.9)
11	122(20)		34.8(34.9)	3.1(3.2)	55.3(55.2)	2.9(3.1)
12	78(0.2)		36.5(36.5)	3.5(3.5)	53.4(53.5)	3.1(3.0)
13	88(0.2)		33.7(33.7)	3.0(3.1)	53.3(53.3)	3.0(3.0)
14		103.0**	35.4(35.3)	3.5(3.6)	51.8(51.9)	5.7(5.9)

* Crystallises slowly on long standing.

** From n-hexane.

TABLE 3

^1H NMR data for compounds **3** - **14**

$R_F = CF_3CF_2CF_2(CF_3)_2C-$

Compound	Chemical shift δ(p.p.m.)*	Coupling constant J(Hz)
1	2	3
a b c $R_FCH_2\underset{\underset{OH}{|}}{C}HCH_2NH_2$ **3**	H_a = 2.33 $H_{a'}$ = 2.38 H_b = 3.96 H_c = 2.57 $H_{c'}$ = 2.80 OH,NH = ca. 2.35**	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 12.4
a b c d $R_FCH_2\underset{\underset{OH}{|}}{C}HCH_2NHCH_3$ **4**	H_a = 2.23 $H_{a'}$ = 2.40 H_b = 4.06 H_c = 2.49 $H_{c'}$ = 2.61 H_d = 2.43(s) OH,NH = ca. 2.78**	$H_aH_{a'}$ = 16.1 $H_cH_{c'}$ = 11.9
a b c d e $R_FCH_2\underset{\underset{OH}{|}}{C}HCH_2NHCH_2CH_3$ **5**	H_a = 2.22 $H_{a'}$ = 2.40 H_b = 4.05 H_c = 2.48 $H_{c'}$ and H_d - overlaping signals H_e = 1.10(t)	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 11.9 H_dH_e = 7.2
a b c d $R_FCH_2\underset{\underset{OH}{|}}{C}HCH_2NHC(CH_3)_3$ **6**	H_a = 2.26 $H_{a'}$ = 2.41 H_b = 3.89 H_c = 2.35 $H_{c'}$ = 2.74 H_d = 1.11(s)	$H_aH_{a'}$ = 16.1 $H_cH_{c'}$ = 11.8

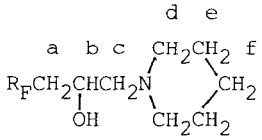
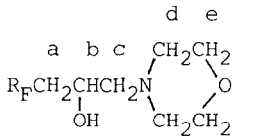
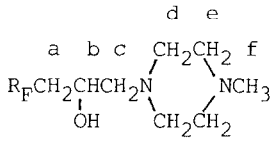
(continued)

TABLE 3 (cont.)

1	2	3
a b c d e f $R_FCH_2CHCH_2NHCH_2CH_2N(CH_3)_2$ OH **7**	H_a = 2.21 $H_{a'}$ = 2.38 H_b = 4.23 H_c = 2.49 $H_{c'}$ = 2.72 H_d = 2.38 and 2.42 H_e = 2.72(t) H_f = 2.23(s)	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 12.4
a b c d e f g $R_FCH_2CHCH_2NHCH_2CH_2CH_2N(CH_3)_2$ OH **8**	H_a = 2.33 $H_{a'}$ = 2.38 H_b = 4.02 H_c = 2.46 $H_{c'}$ and H_d - overlaping signals H_e = 1.64(qn) H_f = 2.34(t) H_g = 2.21(s)	$H_aH_{a'}$ = 16.4 $H_cH_{c'}$ = 12.2
a b c d $R_FCH_2CHCH_2N(CH_3)_2$ OH **9**	H_a = 2.18 $H_{a'}$ = 2.38 H_b = 4.01 H_c = 2.21 $H_{c'}$ = 2.28 H_d = 2.29(s)	$H_aH_{a'}$ = 16.3 $H_cH_{c'}$ = 11.8
a b c d e $R_FCH_2CHCH_2N(CH_2CH_2OH)_2$ OH **10**	H_a = 2.12 $H_{a'}$ = 2.40 H_b = 4.11 H_c = 2.40 $H_{c'}$ = 2.49 H_d = 2.50 and 2.78 H_e = 3.56 and 3.72 OH = ca. 4.3**	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 13.0
d e a b c CH_2CH_2 $R_FCH_2CHCH_2N$ OH CH_2CH_2 **11**	H_a = 2.22 $H_{a'}$ = 2.39 H_b = 4.04 H_c = 2.33 $H_{c'}$ = 2.58 H_d = 2.48 and 2.70 H_e = 1.78 OH = ca. 3.86**	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 11.8

(continued)

TABLE 3 (cont.)

1	2	3
 **12**	H_a = 2.17 $H_{a'}$ = 2.36 H_b = 4.03 H_c = 2.19 $H_{c'}$ = 2.32 H_d = 2.33 and 2.59 H_e = 1.56 H_f = 1.45 OH = ca. 3.9**	$H_aH_{a'}$ = 16.3 $H_cH_{c'}$ = 12.0
 **13**	H_a = 2.23 $H_{a'}$ = 2.43 H_b = 4.08 H_c = 2.29 $H_{c'}$ = 2.38 H_d and H_e = 2.43, 2.65 and 3,70 OH = ca. 3.6**	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 12.2
 **14**	H_a = 2.21 $H_{a'}$ = 2.38 H_b = 4.05 H_c = 2.28 $H_{c'}$ = 2.70 H_d and H_e = 2.45 and 2.70 H_f = 2.28(s)	$H_aH_{a'}$ = 16.2 $H_cH_{c'}$ = 12.2

* In $CDCl_3$. Protons a, b, and c form ABXMN spin systems; centres of the signals related to internal TMS are quoted.

** Very broad, flat signal.

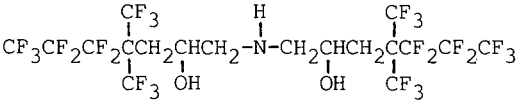
spectra (Table 3). Protons of the $R_FCH_2CHCH_2N$- fragments form characteristic ABXMN (or two ABX) spin systems. From the data collected in Table 3 it can be seen that increasing substitution at the nitrogen

atom leads to a downfield shift of the $-CH_2N-$ group signals as follows:

$-CH_2NH_2$	2.57 and 2.80 ppm
$-CH_2NHR$	2.35 - 2.50 and 2.60 - 2.74 ppm
$-CH_2NR'R''$	2.19 - 2.40 and 2.28 - 2.58 ppm

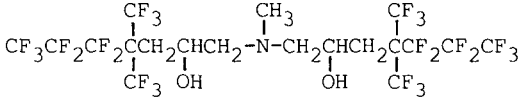
Thus, chemical shifts of the $-CH_2N-$ group protons allow, to some extent, distinction to be made between primary, secondary, and tertiary amines. Signals of the OH and NH groups are very broad (300 - 500 Hz) and could not always be observed. The ^{19}F NMR spectra of the perfluoroalkyl group of compounds **3** - **14** are identical with those previously reported for a number of fluorohydrocarbons of the type $CF_3CF_2CF_2C(CF_3)_2R$ [8].

Primary amine **3** when heated at 90°C with a three-fold excess of epoxide **2** gave bis(2-hydroxy-3-perfluoroalkylpropyl)amine (**15**) in a 73 mol % yield together with a 26 weight % of unidentified white product insoluble in organic solvents and in water.



15

The reaction of epoxide **2** with refluxing methanolic methylamine conducted in an open system gave bis(2-hydroxy-3-perfluoroalkylpropyl)methylamine (**16**) in a 31 % yield, beside the expected hydroxyamine **4**; formation of compound **16** should be explained by the loss of methylamine during the reaction and, therefore, increased epoxide/amine ratio.



16

Compounds **15** and **16** gave satisfactory elemental analyses but their NMR spectra, although, in general consistent with the proposed structures, are too complex to be fully resolved.

EXPERIMENTAL

Boiling and melting points are uncorrected. The NMR spectra were recorded with a Brucker 500 MHz instrument. Purity of the products was checked by the GLC with a Chrom 5 apparatus (Czechoslovakia) using a 3.5 m x 4 mm column packed with Chromosorb G coated with 3 % Silicon Oil SE-52.

3-(Perfluoro-1,1-dimethylbutyl)-1,2-epoxypropane (**2**) was synthesized in this laboratory [7]. Ethanolic solutions of ammonia and dimethylamine were prepared by saturating absolute ethyl alcohol with gaseous ammonia or the amine at ambient temperature. Methylamine and ethylamine were commercial 33 % ethanolic solutions. Other amines were pure grade commercial reagents.

Reactions of epoxide 2 with ammonia and with amines

Reaction conditions and yields of products are given in Table 1.

Reactions with ammonia, methylamine, and dimethylamine were carried out in ca. 100 ml pressure glass ampoule fitted with a Rotaflo valve. The epoxide (1.9 g, 5 mmoles), 10 ml of the ethanolic ammonia or amine solution, and a magnetic stirring bar were placed in the ampoule and heated for the required time while stirring. Other amines (2 - 5 ml) were reacted with the epoxide (1.9 g, 5 mmoles) by refluxing under atmospheric pressure. In the cases of tert-butylamine and diethanolamine 5 ml of ethyl alcohol was added. After the reaction, the solvent and/or excess of the amine were distilled off, the oily residue was mixed with water (20 ml), the organic layer was separated and dissolved in diethyl ether (30 ml). The water was extracted with ether (20 ml) and the combined ether solutions were washed with water and then dried over anhydrous magnesium sulphate. Ether was removed under atmospheric pressure and the residue was subjected to vacuum distillation to give compounds **3** - **14** of ca. 99 % purity (GLC estimate).

Preparation of bis(2-hydroxy-3-(perfluoro-1,1-dimethylbutyl)propyl)-amine (15)

2-Hydroxy-3-(perfluoro-1,1-dimethylbutyl)propylamine (3) (2.0 g, 5 mmoles) and epoxide 2 (5.7 g, 15 mmoles) were stirred together at 90°C for 24 hours. A white insoluble amorphous precipitate (1 g) was filtered off and the filtrate was vacuum distilled. After removal of the excess of the epoxide, compound **15** boiling at 164°C/0.1 Torr was collected (2.8 g, yield 73 %). Colourless, highly viscous liquid; found: C, 28.1; H, 1.5; F, 64.4; N, 1.8%. $C_{18}H_{13}F_{26}NO_2$ requires: C, 28.1; H, 1.7; F, 64.2; N, 1.8%.

Similar results were obtained when increased amount of the epoxide (30 mmoles) or prolonged reaction time was applied.

Preparation of (2-hydroxy-3-(perfluoro-1,1-dimethylbutyl)propyl)-methylamine (4) and bis(2-hydroxy-3-(perfluoro-1,1-dimethylbutyl)propyl)methylamine (16)

Epoxide 2 (1.9 g, 5 mmoles) and 33% ethanolic methylamine (10 ml) were refluxed for 8 hours and then worked up as described above for the reactions with amines. Vacuum distillation gave two fractions: the lower boiling fraction (102°C/20 Torr) was identified as compound 4 (1.3 g, 64 %) and the higher boiling highly viscous fraction (180°C/20 Torr) as compound **16** (0.6 g, 31 %); found: C, 29.1; H, 1.9; F, 63.1; N, 1.9%. $C_{19}H_{15}F_{26}NO_2$ requires: C, 29.1; H, 1.9; F, 63.05; N, 1.8%.

ACKNOWLEDGMENT

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