

Description

The present invention relates to the field of perhalogenated aliphatic hydrocarbons and its subject is more particularly the preparation of perfluoroalkyl bromides or bromoperfluoroalkanes R_F-Br , R_F denoting a linear or branched perfluoroalkyl radical C_nF_{2n+1} containing from 1 to 20 carbon atoms.

These known compounds are employed in many fields, in particular medicine as radioopacifiers (X-ray contrast agents) or as oxygen carriers in blood substitutes. A compound which has been more especially investigated in this field is n-perfluorooctyl bromide $C_8F_{17}Br$.

Among the known methods for preparing these compounds there may be mentioned more particularly:

- the action of bromine on a compound R_F-SF_5 at $500^\circ C$ in the presence of nickel (US Patent 3,456,024),

- the gas phase photolysis of a mixture of 1-hydroperfluoroalkane and of $BrCl$ or BrF (Adcock et al., Chem. Abstr. 100: 34092 e),

- the action of bromine on the compounds R_F-I in the presence of a radical initiator like AIBN (Japanese Application Kokai 85-184,033),

- the photobromination of these same iodine compounds using UV irradiation (Huang et al., Huaxue Xuebao 1984, 42(10) 1106-8 summarized in Chem. Abstr. 102: 78312 x).

The paucity of the yields obtained and/or the slow kinetics of these methods mean that they do not allow perfluoroalkyl bromides to be produced economically on an industrial scale. In view of the importance of these compounds in the medical field it is of the greatest interest to be able to manufacture them at the lowest possible cost.

A technique has now been found enabling perfluoroalkyl bromides to be manufactured from the corresponding perfluoroalkanesulfonyl chlorides R_F-SO_2Cl in a single stage, in an excellent yield and with very good selectivity. When compared with existing methods, the

process according to the invention corresponding to the following reaction scheme:



additionally offers many advantages, especially:

- 5 - simple technology: use of conventional equipment (stirred reactor, moderate temperature, atmospheric pressure, and the like),
- fast kinetics, resulting in a high space/time output, capable of reaching approximately 0.5 moles/-
- 10 hour/litre of reactor,
- safety in operation: simultaneous and controlled removal of hydrochloric acid and of sulphur dioxide.

15 The process according to the invention is characterized in that it consists in reacting gaseous hydrogen bromide with a perfluoroalkanesulphonyl chloride in the presence of a catalyst consisting of a tertiary amine or phosphine or a quaternary ammonium or phosphonium salt at a temperature which can range from 80 to 200°C and,

20 preferably between 90 and 150°C. The optimum temperature depends on the number of carbon atoms in the sulphonyl chloride employed and its purity. Thus, for example, in the case of the freshly distilled sulphonyl chloride $C_8F_{17}SO_2Cl$, it is approximately 120-140°C and in the case

25 of $C_8F_{13}SO_2Cl$ approximately 90-120°C.

 The process according to the invention is preferably carried out at atmospheric pressure, but it would not constitute a departure from the scope of the invention to operate at slightly increased or reduced pressure. It is possible to operate in a reactor fitted with

30 conventional stirring, heating and gas entry devices and supporting a condenser connected to a device for knocking out the vent-off (HCl , SO_2 and unconverted HBr).

 The quantity of catalyst to be employed can vary

35 within wide limits, but is generally between 0.1 and 5 moles per 100 moles of perfluoroalkanesulphonyl chloride, and preferably from approximately 1 to 2 moles per 100. Examples of catalysts to be employed according to the invention which may be mentioned are methyldioctyl-

amine, triphenylphosphine and more particularly tetrabutylammonium bromide, methyltrioctylammonium chloride, dimethyldioctylammonium chloride and tetrabutylphosphonium bromide.

5 Although it is possible to operate in a solvent which is inert towards hydrogen bromide, it is preferred to operate in the absence of any solvent, care being taken that the temperature chosen for the reaction should be sufficient to liquefy the reaction mixture.

10 The rate of flow of gaseous hydrogen bromide which is introduced into the reaction mixture consisting of perfluoroalkanesulphonyl chloride, preferably freshly distilled, and the catalyst, and which is heated to the appropriate temperature, may vary within wide limits. A
15 fast flow rate promotes the space/time output, whereas a slow flow rate promotes the yields based on the HBr introduced. Without this constituting any limitation whatsoever on the field of the invention, an hourly flow rate of hydrogen bromide of the order of 0.1 to 0.5 moles
20 per mole of perfluoroalkanesulphonyl chloride has been found particularly favourable. Whatever the flow rate chosen, the reaction is considered to be finished when there is not further release of SO₂ or of HCl in the vent-off.

25 The following examples illustrate the invention without limiting out.

EXAMPLE 1

282 g of crude perfluorooctanesulphonyl chloride (purity: 92 %, that is 0.5 moles of C₈H₁₇-SO₂Cl) and 3.2 g
30 (0.01 mole) of tetrabutylammonium bromide are placed in a 250-ml reactor fitted with a rotary stirrer (~500 rev/min), a temperature measuring device, a gas injector and a cold-water condenser connected to a bubbler.

35 The mixture is heated to approximately 125°C and gaseous hydrogen bromide is introduced into it, with stirring, for 4 and half hours at a flow rate of 0.13 moles/hour. Measurement of the gaseous vent-off shows a total release of 0.445 moles of HCl, 0.11 moles

of HBr and of 0.47 moles of SO₂.

The reaction mixture is then degassed with nitrogen for an hour, and is then filtered at room temperature to remove the supernatant solid. 250.5 g of a brick-red liquid are thus recovered, and its GC analysis shows that it contains 0.47 moles of C₈F₁₇Br, that is a 94 % yield.

After removal of the residual acidity and distillation at atmospheric pressure (b.p. = 146°C), a product whose purity is better than 99.5 % is obtained.

EXAMPLE 2

The procedure is as in Example 1, but with tetrabutylammonium bromide replace with 3.4 g (0.01 mole) of tetrabutylphosphonium bromide.

250.2 g of crude product containing 90.7 % of C₈F₁₇Br are obtained, which can be purified as in Example 1.

EXAMPLE 3

The procedure is as in Example 1, but with tetrabutylammonium bromide replaced with 4 g (0.01 mole) of methyltrioctylammonium chloride (Aliquat 336) and with the hydrogen bromide being introduced at a rate of 0.17 moles/hour for 5 hours.

254 g of crude product containing 0.43 moles of C₈F₁₇Br are obtained.

Yield: 86 %.

EXAMPLE 4

1847 g of C₈F₁₇SO₂Cl with a GC purity of 90.5 % (that is 3.22 moles of C₈F₁₇SO₂Cl) and 22.4 g of tetrabutylammonium bromide are charged into a 2-litre reactor fitted with a mechanical stirrer, a temperature measuring device, a gas injection leg and a vertical condenser connected to a scrubber column containing water.

The reaction mixture is heated to about 127°C and anhydrous HBr is introduced for 4 hours at a rate of 1 mole/hour.

After degassing with nitrogen for 1 hour and removing the supernatant solid by filtration at room temperature, a brick-red liquid weighing 1730 g is

recovered, which has a GC purity of 88.5 %, that is 3.07 mols of $C_8F_{17}Br$, corresponding to a 95 % yield.

A product which has a purity ≥ 99.5 % is recovered by distilling this crude reaction product at atmospheric pressure.

Determination of the gaseous blow-off shows a total release during the reaction of 3.09 moles of HCl and of 2.90 moles of SO_2 .

EXAMPLE 5

The procedure is as in Example 1, but with tetrabutylammonium bromide replaced with 2.5 g (0.01 mole) of methyldioctylamine.

256.5 g of crude product containing 61.5 % of $C_8F_{17}Br$ are obtained. Yield: 63 %.

EXAMPLE 6

When the procedure is as in Example 1, but with tetrabutylammonium bromide replaced with 2.6 g (0.01 mole) of triphenylphosphine, 278 g of crude product containing 57 % of $C_8F_{17}Br$ are recovered. Yield: 64 %.

EXAMPLE 7

251 g of freshly distilled (99.4 % purity) perfluorohexanesulphonyl chloride, that is 0.6 moles of $C_6F_{13}SO_2Cl$, and 3.9 g of tetrabutylammonium bromide are charged into the same apparatus as in Example 1.

The reaction mixture is heated to 120°C and anhydrous HBr is introduced for 5 hours at a rate of between 0.3 and 0.1 mole/hour. The temperature of the reaction mixture quickly becomes steady at 95-100°C because of the reflux of the $C_6F_{13}Br$ formed. Determination of the gaseous blow-off shows a total release of 0.58 moles of HCl, 0.575 moles of SO_2 and 0.68 moles of HBr.

After degassing with nitrogen for an hour and separating off the catalyst, 229 g of an organic phase containing 96.8 % of $C_6F_{13}Br$ are recovered, that is a 92.6 % yield.



CLAIMS

1. Process for the preparation of perfluoroalkyl bromides, characterized in that it consists in reacting gaseous hydrogen bromide with a perfluoroalkanesulphonyl chloride in the presence of a catalyst consisting of a tertiary amine or phosphine or a quaternary ammonium or phosphonium salt at a temperature ranging from 80 to 200°C.
2. Process according to Claim 1, in which 0.1 to 5 moles of catalyst are used per 100 moles of perfluoroalkanesulphonyl chloride, preferably approximately 1 to 2 moles per 100.
3. Process according to Claim 1 or 2, in which the catalyst is tetrabutylammonium bromide, methyltrioctylammonium chloride, dimethyldioctylammonium chloride or tetrabutylphosphonium bromide.
4. Process according to one of Claims 1 to 3, in which the operation is carried out between 90 and 150°C.
5. Process according to one of Claims 1 to 4, in which the hourly flow rate of hydrogen bromide is of the order of 0.1 to 0.5 mole per mole of perfluoroalkanesulphonyl chloride.
6. Process according to one of Claims 1 to 5, in which perfluorooctyl bromide is formed by starting from perfluorooctanesulphonyl chloride.



As printed

- 7 -

Patentansprüche

1. Verfahren zur Herstellung von Perfluoralkylbromiden, dadurch gekennzeichnet, daß man gasförmigen Bromwasserstoff mit einem Perfluoralkansulfonylchlorid bei einer Temperatur von 80 bis 200°C in Gegenwart eines Katalysators reagieren läßt, der aus einem tertiären Amin oder

Phosphin oder einem quartären Ammonium- oder Phosphoniumsalz zusammengesetzt ist.

2. Verfahren nach Anspruch 1, worin man 0,1 bis 5 mol Katalysator pro 100 mol und vorzugsweise etwa 1 bis 2 mol pro 100 mol Perfluoralkansulfonylchlorid einsetzt.

3. Verfahren nach Anspruch 1 oder 2, worin der Katalysator Tetrabutylammoniumbromid, Methyltrioctylammoniumchlorid, Dimethyldioctylammoniumchlorid oder Tetrabutylphosphoniumbromid ist.

4. Verfahren nach einem der Ansprüche 1 bis 3, worin man zwischen 90 und 150°C arbeitet.

5. Verfahren nach einem der Ansprüche 1 bis 4, worin der stündliche Durchsatz des Bromwasserstoffs in der Größenordnung von 0,1 bis 0,5 mol pro mol Perfluoralkansulfonylchlorid beträgt.

6. Verfahren nach einem der Ansprüche 1 bis 5, worin man vom Perfluorooctansulfonylchlorid zur Bildung des Perfluorooctylbromids ausgeht.

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1. Process for the preparation of perfluoroalkyl bromides, characterized in that it consists in reacting gaseous hydrogen bromide with a perfluoroalkanesulfonyl chloride in the presence of a catalyst consisting of a tertiary amine or phosphine or a quaternary ammonium or phosphonium salt at a temperature ranging from 80 to 200°C.

2. Process according to Claim 1, in which 0.1 to 5 moles of catalyst are used per 100 moles of perfluoroalkanesulfonyl chloride, preferably approximately 1 to 2 moles per 100.

3. Process according to Claim 1 or 2, in which the catalyst is tetrabutylammonium bromide, methyltrioctylammonium chloride, dimethyldioctylammonium chloride or tetrabutylphosphonium bromide.

4. Process according to one of Claims 1 to 3, in which the operation is carried out between 90 and 150°C.

5. Process according to one of Claims 1 to 4, in which the hourly flow rate of hydrogen bromide is of the order of 0.1 to 0.5 mole per mole of perfluoroalkanesulfonyl chloride.

6. Process according to one of Claims 1 to 5, in which perfluorooctyl bromide is formed by starting from perfluorooctanesulfonyl chloride.