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SYNTHESIS OF 1,2-AMINOAZIDES. CONVERSION TO UNSYMMETRICAL VICINAL DIAMINES BY CATALYTIC HYDROGENATION OR REDUCTIVE ALKYLATION WITH DICHLOROBORANES.

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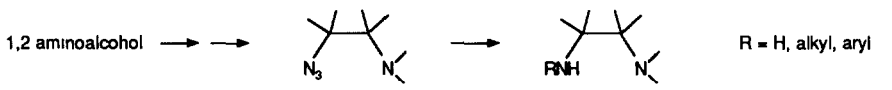
Abstract : 1,2-aminoazides are easily prepared from 1,2-amino alcohols. Catalytic hydrogenation in the presence of palladium on charcoal or reductive alkylation with dichloroboranes afford with good yields unsymmetrically substituted vicinal diamines.

Introduction

Vicinal diamine derivatives have been frequently encountered in biogically active substances [1]. They are also of great importance in metal chelation [2] and are useful synthetic intermediates in heterocyclic chemistry [3]. Furthermore, in recent years, C_2-symmetric 1,2-diamines and their derivatives were widely used as chiral auxiliaries for enantioselective versions of several powerful synthetic transformations [4]. Several methods are available for the preparation of these interesting molecules.

β-haloamines undergo nucleophilic substitution with amines, but this simple approach is of limited applicability [5] and more sophisticated synthesis have been further developped. The conversion of alkenes to vicinal diamines has been achieved by reduction of diazides [6], 2,3-dihydroimidazoles [7], β-azidoalkylphosphoramidates [8], β-azidoalkylurethanes [9] and by diamination procedures mediated by organometallic reagents [10]. The ring opening of aziridines by amines or by amino derivatives is only efficient when starting from symmetrical compounds or if the regioselectivity can be controlled [11]. Reductive dimerizations of Schiff bases can be induced by a variety of reagents, electrochemically or by irradiation but, obviously, produce only symmetrical compounds [12]. Alternatively, vicinal diamines can also be obtained by reductive amination of α-amino ketones [13], reduction of α-amino enamines [14], α-amino and α-(N-acylamino) amides [15], α-amino nitriles [16], α-amino imines [17] and dialkyl- or tetraalkyloxamides [18]. Diels-Alder reactions of sulfur dioxide bis (imides) with various 1,3-dienes lead stereoselectively to unsaturated vicinal diamines [19] and a variety of symmetrical 1,2-diamines were readily prepared from glyoxal, benzotriazole and secondary or primary amines [20]. More recently, attractive synthesis of homochiral diamines from cyclic sulphamidates [21b], sulfites [21c] or sulfates [21d] and from N,N-dibenzylaminoaldehydes [17b] have been developped.

We report here an efficient and versatile synthesis of vicinal unsymmetrical diamines based on the reduction or on the reductive alkylation of 1,2-aminoazides as illustrated below.



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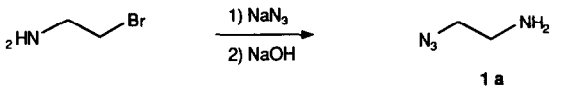
I - Synthesis of 1,2-aminoazides

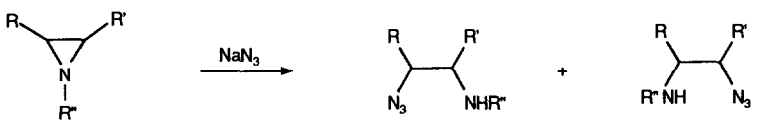
Numerous examples of bifunctionnal compounds with both an azido group and an other function X (X = OR, SR, CO_2R, ...) have been described in the litterature [22], but, surprisingly, at the beginning of our work, only a few azides **1** have been previously described.

The first 1,2-aminoazide **1a** was obtained in 1911 by M.O. Forster et al from β-bromoethylamine hydrobromide [23]. Similar compounds were prepared later by the same method [24], but, except in a very few cases [8,24c], none of them have substituents on the carbon chain.

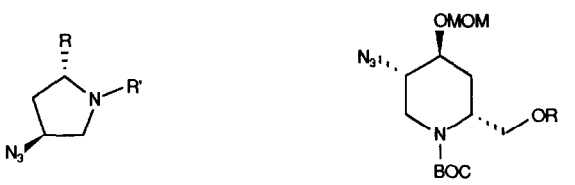


1 a

Ring opening of unsymmetrically substituted aziridines by sodium azide in the presence of ammonium chloride produces a mixture of regioisomers [25]. However, in some cases, for example with carbohydrate derivatives, the regioselectivity can be controlled [26].



While our work was in progress, **1a** as its N-tertiobutyloxycarbonyl derivative [27] and the azides **2** [28] and **3** [29] were synthesized from the related N-protected 1,2-aminoalcohol.

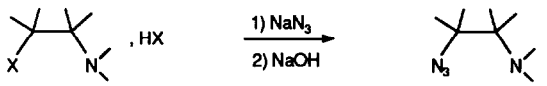


2 R = H, CH_3, CO_2Me
R' = BOC, CH_2Ph

3

I.A - Reactivity and stereochemistry of the reaction of β-haloamines with sodium azide

1,2-Aminoazides **1** were prepared by the route reported by M.O. Forster [23]. The starting β-haloamines hydrohalides **4** were, either commercially available, or easily accessible from the corresponding 1,2- aminoalcohols by known methods [30].



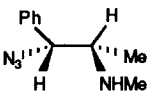
4 X = Cl, Br **1**

This approach provides an easy access to β-azidoethylamines with good yields, except for **1c**. A mixture of isomers is obtained when starting from unsymmetrically substituted substrates (table I, entries 4, 5 and 7).

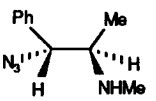
Table I. Synthesis of ω-aminoazides **1** from halides **4**.

Entry	Halide	Azide	Isolated Yield (%)
1	Br-$(CH_2)_2$-NH_2, HBr **4A**	N_3-$(CH_2)_2$-NH_2 **1a**	77
2	Br-$(CH_2)_2$-NHMe, HBr **4B**	N_3-$(CH_2)_2$-NHMe **1b**	73
3	Cl-$(CH_2)_2$-N⟨⟩, HCl **4C**	N_3-$(CH_2)_2$-N⟨⟩ **1c**	45
4	(±) Cl-CHMe-CH_2NH_2, HCl **4D**	N_3-CHMe-CH_2NH_2 **1d** + N_3-CH_2-CHMeNH_2 **1e** (30 / 70) [1]	71
5	(±) Cl-CHMe-CH_2-NMe_2, HCl **4E**	N_3-CHMe-CH_2-NMe_2 **1f** + N_3-CH_2-CHMe-NMe_2 **1g** (60 / 40)[1]	65
6	(1R,2S)- Cl-CHPh-CHMe-NHMe, HCl **4F**	(1R,2S)- N_3-CHPh-CHMe-NHMe **1h**	90
7	(1R,2R)- Cl-CHPh-CHMe-NHMe, HCl **4G**	(1R,2R)- N_3-CHPh-CHMe-NHMe **1i** + (1S,2S)-N_3-CHMe -CHPh-NHMe **1j** + (1S,2R)- N_3-CHPh-CHMe-NHMe **1h'** (91/6/3)[1]	78

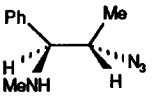
[1] estimated on the 300 MHz ^{1}H NMR spectrum of the crude reaction mixture.



1 h (erythro)



1 i (threo)

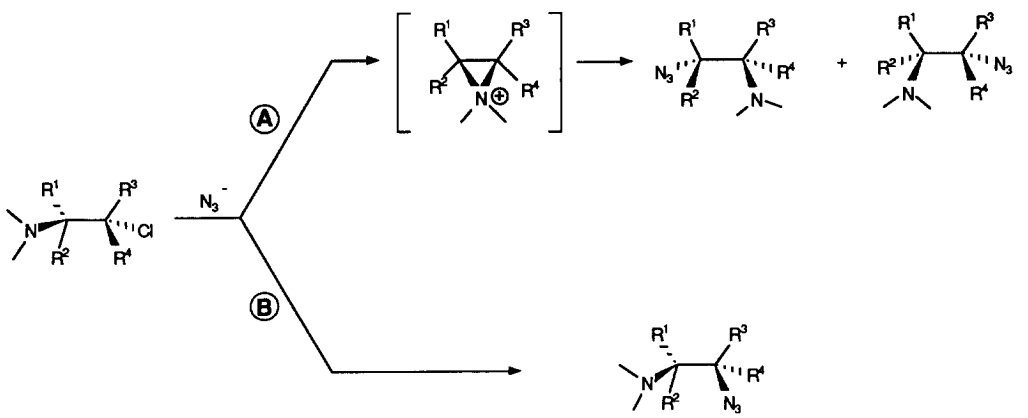


1 j (threo)

Aminoazides **1a-1h** exhibit spectroscopic data (^1H, ^{13}C NMR, IR) in agreement with the proposed structures. **1d** and **1e** are unambiguously identified by comparaison with pure isomers prepared by an other route (see next paragraph) and **1f** and **1g**, which have very similar structures, by analogy with **1d** and **1e**.The determination of the structure of **1h, 1f** and **1g** relies on the following observations: For **1h**, a diagnostic ion in mass spectroscopy (m/z = 58, relative intensity : 70%, $MeCH{=}NHMe^+$) results from a cleavage in the β-position of two nitrogen atoms and establishes the regioselectivity of the reaction of NaN_3 with **4F.** It is also confirmed by the ^1H NMR chemical shift of the CH-Ph: 4.54 and 4.31 ppm for **1h** and**1i** respectively where the proton is in an α- position of the azido group compared to the chemical shift of the benzylic proton in **1j**: 3.28 ppm where it is in an α-position of an amino group. The stereochemistry was attributed on the basis of the values of the coupling constants $^3J_{H\text{-}H}$: 5.7 Hz for the erythro derivative **1h** and 8.5 Hz for the threo derivatives **1i** and **1j.** These values are very similar to those given in the litterature for the corresponding hydroxy - and chloro derivatives; erythro : $^3J_{H\text{-}H}$ = 3,9 (ephedrine) and 5.4 respectively; threo : 8.2 (pseudo-ephedrine) and 8.4 respectively [30c].

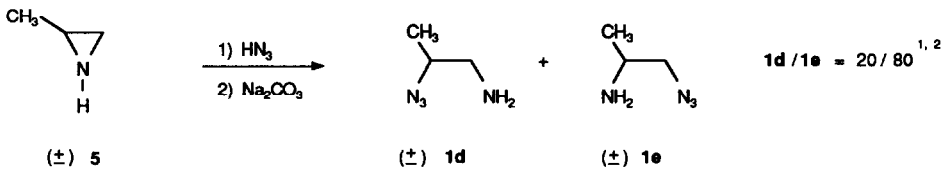
mechanism

The formation of mixtures of regioisomers suggest that azidation involves a more complex process than a simple nucleophilic substitution of the halogen atom. It is well established that β-haloamines readily undergo ring closure in basic medium to give aziridines [31]. Our results can be interpreted by a preliminary deprotonation of the hydrochloride by N_3^- , acting as a base. The free haloamine then cyclises to the aziridinium salt [8] and subsequent ring opening provides one or two regioisomers having the same relative configuration as the starting product (path A).

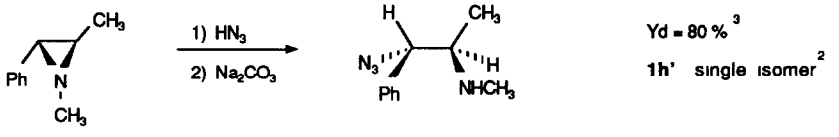


Direct substitution of the halogen atom (path B) cannot be completely excluded (for example, formation of small amounts of **1j** from **4G**), but it is not usually observed (see the other examples and ref. 8). It is noteworthy that the isomer distribution is greatly influenced, not only by the substitution, but also by the stereochemistry of the starting product as it has been encountered for epoxides [32].

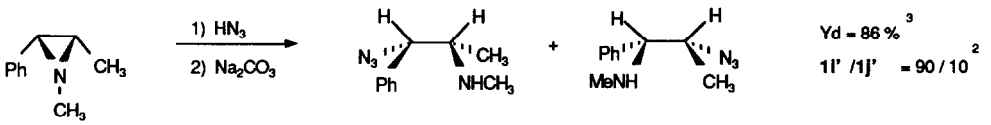
The knowledge of the stereochemistry and isomers distribution in the ring opening of pure aziridines would be therefore of value for mechanistic considerations. The reactions of aziridines **5**, **6**, **7** [33] with HN_3 were investigated and led to the following results: **5** gives a 20/80 mixture of the two regioisomers **1d** and **1e** respectively. Only one isomer **1h'** was obtained from the trans 2,3-disubstituted aziridine **6** whereas the cis aziridine **7** led to a 9/1 mixture of **1i'** and **1j'*** .



(±) **5** (±) **1d** (±) **1e**



(1R, 2R) **6** (1S, 2R) **1h'**



(1R, 2S) **7** (1S, 2S) **1i'** (1R, 2R) **1j'**

[1] complex crude reaction mixture Attempts of purification were unsuccessfull

[2] estimated on the 300 MHz ^1H NMR spectrum of the crude reaction mixture

[3] Isolated yields.

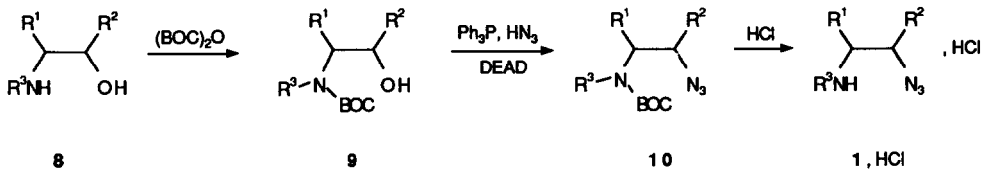
* The ring opening of aziridines **6** and **7**, prepared from (1S, 2R) (+) ephedrine and (1S, 2S) (+) pseudoephedrine respectively, led to **1h'**, **1i'** or **1j'**, enantiomers of the products obtained by reaction of **4F** and **4G** with NaN_3.

From these results, it can be concluded that the reactions of β-haloamines with sodium azide mostly involve the formation of an aziridinium intermediate. Direct substitution of the halogen atom only occurs in small extent in some very few particular cases. The obtention of homochiral aminoazides **1h** and **1h'**, either from **4F** or **6**, is also worthy of note [34].

This very simple route to 1,2-aminoazides has therefore a major disadvantage since the aziridinium intermediate is usually responsible for the obtention of mixture of isomers. Temporary protection of the amino group prevents such an undesirable behaviour as it is shown below.

I.B - Synthesis of 1,2-aminoazides from 1,2-aminoalcohols

Numerous methods are available for obtaining 1,2-aminoalcohols with complete control of stereochemistry [35]. We have used these compounds as starting materials for the preparation of 1,2-aminoazides according to the following scheme.



8 **9** **10** **1, HCl**

Preliminary protection of the amino group in **8** by reaction with di-tert-butyldicarbonate followed by treatment of the N-protected aminoalcohols **9** with PPh_3, DEAD and HN_3 affords the corresponding azides **10** [36]. Deprotection with hydrochloric acid provided the stable β-aminoazide hydrochlorides in good overall yield (table II).

Table II. Synthesis of 1,2 aminoazides from 1,2 aminoalcohols.

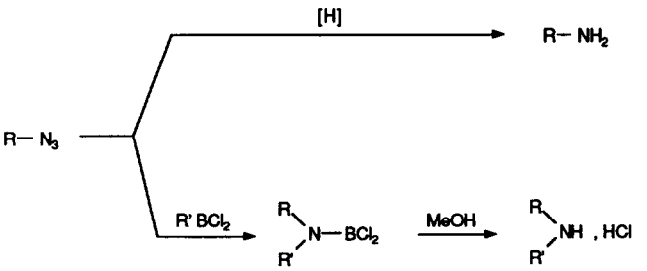
Azide	R^1	R^2	R^3	**8→9** (%)(a)	**9→10** (%) (a)	**10→HCl** (%)(a)	Overall yield(a)
1d	H	Me	H	75	81	72	44
1k	H	Me	Me	96	83	78	62
1e	Me	H	H	86	73	76	48
1l	Et	H	H	95	82	72	56
1m	Ph	H	H	83	73	98	59
1n	H	Ph	H	86	60	92	47

(a) Isolated yields.

All these compounds have been fully characterized spectroscopically (^1H, ^{13}C NMR, IR). The possibility of the synthesis of homochiral aminoazides from the corresponding aminoalcohols remains to be explored.

II - Synthesis of 1,2-diamines

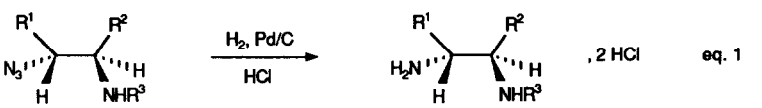
The conversion of an azido group into a primary amine constitutes a synthetically very important process which may be achieved by using a large variety of reagents [22]. The reductive alkylation of azides with boranes was discovered some years ago by H.C.Brown et al. and provides an efficient route to secondary amines [37,38].



1,2-Aminoazides **1** can therefore be converted by two possible routes to vicinal diamines i.e. by catalytic hydrogenation in acidic medium leading to **11**, 2 HCl (eq. 1) or starting from **1**, HCl by reductive alkylation with dichloroboranes followed by methanolysis thus giving the dihydrochlorides **12**, 2 HCl (eq. 2).

II.a - Catalytic hydrogenation of 1,2-aminoazides 1

The reduction of **1** with H_2 in the presence of palladium on charcoal in EtOH gives the corresponding 1,2-diamine dihydrochlorides in good yield (table III).



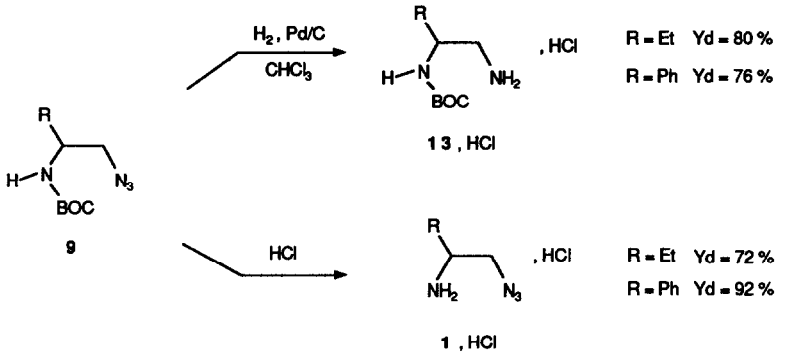
1 11 , 2 HCl

Table III - Synthesis of 1,2-diamines **11**, 2 HCl

R^1	R^2	R^3	Yield (%)[a]
H	Me	H	97
Ph	H	H	98
Me	H	Me	96
Me	Ph	Me	98

a Isolated yields

It is also possible to reduce the N-tertiobutyloxycarbonylaminoazides **10**, in the presence of a small amount of chloroform which serves as the hydrogen chloride source [39]. The monoprotected 1,2-diamine hydrochlorides **13**,HCl are then obtained, whereas the treatment of **10** with hydrochloric acid produces the 1,2-aminoazide hydrochlorides **1**,HCl as previously described .



It is therefore possible to choose the free primary amino group either CH_2-$\underline{NH_2}$ as in **13** or RCH-$\underline{NH_2}$ as in **1**. This of course allows to perform reactions regiospecifically at the selected center.

Details about the synthesis of various heterocycles and acyclic polyamino derivatives, taking advantage of these particular features, will appear in separate papers.

II.b - Reactions of 1,2-aminoazide hydrochlorides with dichloroboranes.

Dichloroboranes react readily with organic azides at room temperature and produce with good yields pure secondary amines. The reaction possesses good chemioselectivity and proceeds with complete retention of stereochemistry of the alkyl group in the starting borane [37,38]. Furthermore, this approach prevents the formation of any polyalkylation products usually observed, for example, in the reaction of amines with alkyl halides. 1,2-aminoazides **1**, as their hydrochlorides as a temporary protection of the amino moiety, react with alkyl- or aryl dichloroboranes in dry dichloromethane to lead, after methanolysis, to the corresponding secondary amines dihydrochlorides **12**, 2 HCl (eq. 2). The obtained results are reported in table IV.

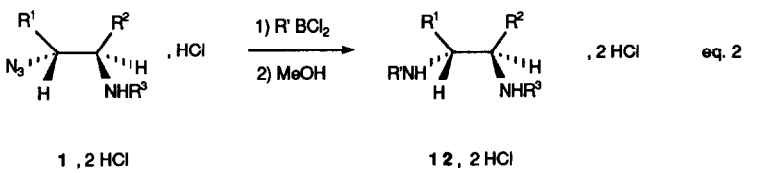


Table IV - Synthesis of 1,2-diamines hydrochlorides **12**, 2 HCl.

Entries	R^1	R^2	R^3	R'	Yield (%)[a]
1	H	H	H	C_6H_{11}	89
2	H	H	H	Ph	81
3	Et	H	H	C_6H_{13}	85
4	H	H	Me	C_6H_{13}	79
5	H	H	Me	Ph	81

a Isolated yields

Good yields are usually obtained and the very efficient phenylation reaction at nitrogen (entries 2 and 5, Table IV) is worthy of note.

In conclusion, 1,2-aminoazides, easily prepared from 1,2-aminoalcohols, are valuable starting materials for the synthesis of unsymmetrically substituted 1,2-diamines.The azido group may be reduced either to a primary amine with hydrogen in the presence of palladium on charcoal or to a secondary amine via the reductive alkylation with dichloroboranes. These simple methodologies open an easy access to a wide variety of vicinal unsymmetrical diamines which are important intermediates for the synthesis of heterocycles and more sophisticated polyamino derivatives.

Experimental section

^1H and ^{13}C NMR spectra were recorded at 300 and 75.5 MHz respectively with a Bruker AM 300 Spectrometer in $CDCl_3$ or D_2O as solvents. Chemical shifts are reported in δ, parts per million (ppm) and coupling constants are given in Hertz. Multiplicities are abbreviated as follows : s : singlet, d : doublet, t : triplet, q : quartet, m : multiplet, br : broad. Infrared spectra were recorded on a Perkin Elmer 1420 spectrometer. Optical rotations were determined with a Perkin Elmer 141 polarimeter. The mass spectra were recorded on a Varian MAT 311 at 70 eV (Centre regional de mesures physiques de l'Ouest, Rennes).Combustion analysis were performed at the Laboratoire Central d'Analyse du C.N.R.S. at Lyon.

CAUTION : Because of their potentially explosive character and the high toxicity of HN_3, all reactions involving 1,2 aminoazides were carried out with the appropriate protection under a well ventilated hood.

I - Synthesis of 1,2-aminoazides 1

β-haloamines hydrochlorides or hydrobromines **4A**, **4C**, **4E** are commercially available. **4B** is obtained by treatment of N-methylaminoethanol with HBr [30a] and **4D** from 1-amino 2-propanol and thionylchloride [30b]. The reaction of (1S, 2R)(+) ephedrine with PCl_5 in CH_2Cl_2 gives **4G** in 73 % yield[30c]. (1S, 2S)(+)-pseudoephedrine under the same conditions led to a mixture of (1R, 2S) and (1S, 2S) chloro analogs (57/43) in 52 % yield[30c]. The pure (1R, 2S) derivative **4F** is obtained after two recristallisations from ethanol .

Ia - Reaction of 4 with NaN_3

General procedure : A solution of 20 mmoles of β-haloamine hydrochlorides or hydrobromines **4** and 60 mmoles of sodium azide in 20 ml of water was heated 15 hours at 80°C. After removing about 10 ml of water by distillation under vacuum, the resulting solution was cooled in an ice bath. Ether (100 ml) and, then, solid KOH (8 g) were added, keeping the temperature below 10°C. After separation of the organic phase the aqueous layer was further extracted with ether (2 x 50 ml) and the combined organic layers were dried on K_2CO_3. After removal of the solvent, the azide was purified by bulb to bulb distillation on solid KOH.

*1-Azido-2-aminoethane **1a***

10 g of **4A** gave 3.2 g of **1a**. Yd = 77 %. b.p. = 60-62°C (45 mm Hg) (litt. : ref. 23, b.p. = 63-65°C (50 mm Hg)). ^1H NMR : 1.39 (s, 2H), 2.78 - 2.98 (m, 2H) ; 3.35 (t, 2H, J = 5.7). IR (neat) ν : 2100 (N_3).

*1-Azido-2-(N-methylamino)ethane **1b***

20 g of **4B** gave 6.4 g of **1b**. Yd = 70 %. b.p. = 70-75°C (15 mm Hg). ^1H NMR : 1.55 (s, 1H), 2.42 (s, 3H) ; 2.67 - 2.85 (m, 2H) ; 3.43 (t, 2H, J = 5.7). IR (neat) ν : 2100 (N_3). Anal. calc. for $C_3H_8N_4$, $C_6H_3N_3O_7$ (picrate, m.p. = 116°C):. C, 32.84 ; H, 3.34 ; N, 29.77 ; Found : C, 33.0 ; H, 3.4 ; N, 29.6.

*1-Azido-2-piperidinoethane **1c***

5,4 g of **4C** gave 3.8 g of **1c**. Yd = 46 %. b.p. = 20-25°C (10^{-1} mm Hg). ^1H NMR : 1.28 - 1.72 (m, 6H), 2.25, 2.62 (m, 6H) ; 3.33 (t, 2H, J = 6.2). IR (neat) ν : 2100 (N_3).Anal. calc. for $C_7H_{14}N_4$, $C_6H_3N_3O_7$ (picrate, m.p. = 151°C): C, 40.73 ; H, 4.44 ; N, 25.58 ; Found : C, 40.6 ; H, 4.4 ; N, 25.2.

*2-Azido-3-aminopropane **1d** and 1-azido-2-aminopropane **1e***

800 mg of **4D** gave 470 mg of **1d** and **1e**. Yd = 76 %. bp = 52-58°C (45 mm Hg) (30/70 mixture of **1d** and **1e** respectively).The NMR spectra of each pure isomer are reported in the next paragraph.

*2-Azido-3-(N,N-dimethylamino)propane **1f** and 1-azido-2-(N,N-dimethylamino)propane **1g**.*

2.00 g of **4E** gave 1.16 g of **1f** and **1g**. Yd = 72 %. b.p. = 72-80°C (55 mm Hg) (60/40 mixture of **1f** and **1g** respectively). ^1H NMR (D_2O) (mixture of **1f**, HCl and **1g**, HCl): **1f**, HCl : 1.56 (d, 3H, J = 6.6), 3.06 (s, 6H), 3.75 - 3.87 (m, 1H), 3.92 (dd, 1H, J = 13.7, 8.0), 4.09 (dd, 1H, J = 13.7, 4.2).**1g**, HCl : 1.60 (d, 3H, J = 6.4), 3.13 (s, 6H), 3.34 - 3.46 (m, 2H), 4.30 - 4.41 (m, 1H).IR (neat) ν : 2100 (N_3).Anal. calc. for $C_5H_{12}N_4$, $C_6H_3N_3O_7$ (picrate, mixture of **1f** and **1g**): C, 36.97 ; H, 4.20 ; N, 27.45 ; Found : C, 36.9 ; H, 4.4 ; N, 27.0.

*(1R,2S)-1-Azido-1-phenyl-2-(N-methylamino)propane **1h** :*

2.34 g of **4F** gave 1.83 g of **1h.** Yd = 90 %, bp = 48°C (6.10^{-3} mm Hg), **1h**, HCl $[\alpha]_D^{20}$ -190.2° (c 4.O, H_2O).^1H NMR : 1.02 (d, 3H, J = 6.4), 1.12 (br s, 1H), 2.36 (s, 3H), 2.78 (dq, 1H, J = 6.4 and 5.7), 4.54 (d, 1H, J = 5.7), 7.25 - 7.37 (m, 5H). ^{13}C NMR . 15.3, 33.8, 59.6, 69.6, 127.4, 128.1, 128.6, 137.7. IR (neat) : ν = 2100.(N_3). Mass spectrum (70eV), m/e (relative intensity) 105 (29), 104 (25), 77 (16), 58 (70), 42 (23), 28 (100). Anal. calcd for $C_{10}H_{14}N_4$, HCl, mp = 198°C : C, 52.98 ; H, 6.62 ; N, 24.72. Found : C, 52.8 ; H, 6.7 ; N, 24.5.

(1R,2R)-1-Azido-1-phenyl-2-(N-methylamino)propane ***1i****, (1S,2S)-2-azido-3-phenyl-3-(N-methylamino)propane* ***1j*** *and (1S,2R)-1-azido-1-phenyl-2-(N-methylamino)propane* ***1h'*** *:*

1.00 g of **4G** gave 600 mg of a mixture of **1i,1j** and **1h'**. Yd = 70 %, bp = 34-46°C (6.10^{-3} mm Hg) (**1i/1j/1h'** = 91/6/3). The ratio of the three isomers was calculated from the relative intensities (^{1}H NMR) of the three N-C$\underline{H}_3$ groups. **1i** ^{1}H NMR : 0.83 (d, 3H, J = 6.4), 1.77 (br s, 1H), 2.40 (s, 3H), 2.77 (dq, 1H, J = 8.4 and 6.4), 4.31 (d, 1H, J = 8.4), 7.25 - 7.38 (m, 5H). ^{13}C NMR : 15.8, 33.2, 58.6, 71.3, 127.7, 128.0, 128.4, 137.3. **1j** ^{1}H NMR : 1.04 (d, 3H, J = 6.5), 1.77 (br s, 1H), 2.18 (s, 3H), 3.28 (d, 1H, J = 8.5,), 3.56 (dq, 1H, J = 8.5 and 6.5), 7.25 - 7.38 (m, 5H). ^{13}C NMR : 16.3, 34.1, 62.7, 70.0, 127.8, 128.1, 128.4, 139.8. **1h'** ^{1}H NMR : 1.02 (d, 3H, J = 6.3,), 1.77 (br s, 1H), 2.36 (s, 3H), 2.77 (dq, 1H, J = 5.6 and 6.4), 4.56 (d, 1H, J = 5.6), 7.25 - 7.38 (m, 5H). ^{13}C NMR : 15.1, 33.5, 59.3, 69.5, 127.3, 127.9, 128.5, 137.3. Anal. calcd for $C_{10}H_{14}N_4$, HCl (mixture of **1i**, **1j** and **1h'**): C, 52.98 ; H, 6.62 ; N, 24.72. Found : C, 52.7 ; H, 6.7 ; N, 24.8.

Ib - Reactions of aziridines 5, 6, 7 with HN_3

5 is commercially available. (1R, 2R) **6** and (1R, 2S) **7** were prepared respectively from (1S, 2R) (+) ephedrine and (1S, 2S)(+)-pseudoephedrine[33].

General procedure : To 9 mmoles of aziridine in 10 ml of methylene chloride was added 13 ml of a 2M solution of HN_3 [39] in methylene chloride. The mixture was stirred overnight at room temperature. The solution was brought to pH > 10 with saturated aqueous sodium bicarbonate. After separation of the organic phase, the aqueous layer was extracted with methylene chloride (3 x 20 ml). The combined organic extracts were dried over anhydrous potassium carbonate. Filtration of the drying agent and removal of solvent afforded an oil which is purified by bulb to bulb distillation.

For aziridine **4**, to prevent a modification of the ratio of the volatile regioisomers **1d** and **1e** during the work-up, the following procedure was used : after extraction with methylene chloride, the organic phase was treated directly with 1N hydrochloric acid. The aqueous solution was evaporated under vacuum and the ^{1}H NMR spectrum of the crude mixture was recorded in D_2O. The ratio of the two isomers **1d** and **1e** (**1d/1e** = 20/80) was calculated from relative intensities of the two C-C$\underline{H}_3$ groups. **1d** and **1e** are identified by comparison with pure samples obtained from N-BOC aminoalcohols (see next paragraph).It was not possible to purify efficiently the reaction mixture and, therefore to give a significant yield in aminoazide.

(1S,2R)-1-Azido-1-phenyl-2-(N-methylamino)propane ***1h'*** *:*

1.33 g of **6** gave 1.36 g of **1h'**. Yd = 80 %. b.p. = 40°C (6.10^{-3} mm Hg). **1h'**, HCl $[\alpha]_D^{20}$ +192.8° (c 4.0, H_2O). ^{1}H NMR and ^{13}C NMR spectra are identical to those of its enantiomer **1h**.

(1S,2S)-1-Azido-1-phenyl-2-(N-methylamino)propane ***1i'*** *and (1R,2R)-2-azido-3-phenyl-3-(N-methylamino)propane* ***1j'***.

1.32 g of **7** gave 1.47 g of a mixture of **1i'** and **1j'**. Yd = 86 %. bp = 30-48°C (6.10^{-3} mm Hg) (**1i'/1j'** = 90/10).The ratio of the two isomers was calculated from the relative intensities (^{1}H NMR) of the two N-C$\underline{H}_3$ groups. **1i'** and **1j'** are identified by comparison with their enantiomers **1i** and **1j** described in section **Ia.**

Ic - Synthesis of 1,2-aminoazides from 1,2-aminoalcohols

Synthesis of N-Boc aminoalcohols **9**

To a solution of the aminoalcohol **8** (50 mmoles) in CH_2Cl_2 (50 ml) was added 50 ml of NaOH 1N. The mixture was cooled in an ice bath and di-tert-butyl dicarbonate was added keeping the temperature below 10°C. After stirring overnight at room temperature, the organic layer was separated, washed with water (2 x 20 ml), dried over anhydrous $MgSO_4$ and filtered. The solvent was removed under reduced pressure to give the N-Boc protected alcohol used in the next step without further purification.

1-(N-tert-butoxycarbonylamino)-2-propanol ***9d***

3.76 g of **8** gave 6.60 g of **9d**. Yd = 75 % ; oil.^{1}H NMR : 1.17 (d, 3H, J = 6.3), 1.45 (s, 9H), 2.78 - 3.35 (m, 2H), 3.40 (brs, 1H), 3.65 - 4.08 (m, 1H), 5.33 (brs, 1H). IR (neat) ν : 1690 (CO), 3350 (NH and OH). Anal. calcd. for $C_8H_{17}NO_3$: C, 54.85 ; H, 9.71 ; N, 8.00 ; Found : C, 54.7 ; H, 10.1 ; N, 8.0.

1-(N-Methyl, N-tert-butoxycarbonylamino)-2-propanol ***9k***

4.00 g of **8** gave 8.20 g of **9k**. Yd = 96 % ; oil. ^{1}H NMR : 1.10 (d, 3H, J = 6.3), 1.40 (s, 9H), 2.87 (s, 3H), 3.08 - 3.30 (dm, 2H, J = 6.3) ; 3.37 (brs, 1H), 3.95 (sext, 1H, J = 6.3). IR (neat) ν : 3430 (OH), 1680 (CO). Anal. calcd. for $C_9H_{19}NO_3$: C, 57.14 ; H, 10.05 ; N, 7.40 ; Found : C, 57.3 ; H, 10.1 ; N, 7.3.

2-(N-tert-butoxycarbonylamino)-1-propanol ***9e***

2.25 g of **8** gave 4.50 g of **9e**. Yd = 86 %. mp = 44°C. ^{1}H NMR : 1.12 (d, 3H, J = 6.4), 1.40 (s, 9H), 3.20 (brs, 1H), 3.37 - 3.92 (m, 3H) 4.85 (brs, 1H). IR (Nujol) ν : 3450 (NH), 3360 (OH), 1670 (CO). Anal. calcd. for $C_8H_{17}NO_3$: C, 54.85 ; H, 9.71 ; N, 8.00 ; Found : C, 55.0 ; H, 9.9 ; N, 7.9.

2-(N-tert-butoxycarbonylamino)-1-butanol ***9l***

1.50 g of **8** gave 3.02 g of **9l**. Yd = 95 %. mp = 40°C. ^{1}H NMR : 0.93 (t, 3H, J = 7), 1.05 - 1.75 (m, 2H), 1.45 (s, 9H), 3.08 (bs, 1H), 3.33 - 3.72 (m, 3H), 4.85 (brs, 1H). IR (Nujol) ν : 3350 (NH and OH), 1675 (CO). Anal. calcd. for $C_9H_{19}NO_3$: C, 57.14 ; H, 10.05 ; N, 7.40 ; Found : C, 57.0 ; H, 10.2 ; N, 7.5.

2-(N-tert-butoxycarbonylamino)-2-phenyl-1-ethanol ***9m***

4.23 g of **8** gave 6.10 g of **9m**. Yd = 83 %. mp = 138°C. ^{1}H NMR : 1.42 (s, 9H), 2.72 (brs, 1H), 3.80 (d, 2H, J = 5.4), 4.72 (td, 1H, J = 5.4 and 8.0), 5.40 (brd, 1H, J = 8.0), 7.17 - 7.48 (m, 5H). IR (Nujol) ν : 3300 (NH), 3240 (OH), 1660 (CO). Anal. calcd. for $C_{13}H_{19}NO_3$: C, 65.82 ; H, 8.01 ; N, 5.90 ; Found : C, 65.8 ; H, 8.0 ; N, 6.0.

1-(N-tert-butoxycarbonylamino)-2-phenyl-2-ethanol ***9n***

4.03 g of **8** gave 6.00 g of **9n**. Yd = 86 %. mp = 123°C. ^{1}H NMR : 1.46 (s, 9H), 3.00 (brs, 1H), 3.25 (ddd, 1H, J = 4.0, 6.7 and 14.3), 3.48 (ddd, 1H, J = 5.8, 7.4 and 14.3), 4.75 (dd, 1H, J = 4.0 and 7.4), 4.97 (brs, 1H), 7.27 - 7.48 (m, 5H). IR (Nujol) ν : 3360 (NH and OH), 1670 (CO). Anal. calcd. for $C_{13}H_{19}NO_3$: C, 65.82 ; H, 8.01 ; N, 5.90 ; Found : C, 65.7 ; H, 8.0 ; N, 5.9.

Synthesis of N-Boc aminoazides **10**

To a solution of the N-Boc protected alcohol **9** (20 mmoles) and triphenylphosphine (5.76 g, 22 mmoles) in benzene (100 ml) stirred under nitrogen in an ice bath was slowly added hydrazoic acid (24 mmoles, 11.16 ml of a 2.15 N solution of HN_3 in CH_2Cl_2 [40]) and diethyl azodicarboxylate (3.82 g, 4.2 ml, 22 mmoles). The ice bath was removed, and the mixture was stirred overnight at room temperature. Benzene was distilled in vacuum. 100 ml of a 1/1 mixture of hexane/ether was then added to the residue. Triphenylphosphine oxide and diethyl hydrazine dicarboxylate were filtered off and washed with hexane/ether (1:1, 50 ml). After removal of the solvents, the residue was chromatographied on silica gel eluting with hexane/ether (60/40).

1-(N-tert-butoxycarbonylamino)-2-azidopropane ***10d***

3.60 g of **9d** gave 3.35 g of **10d**. Yd = 81 %. Oil (Rf = 0.5, eluant : hexane/ether, 60/40). ^1H NMR : 1.20 (d, 3H, J = 6.5), 1.42 (s, 9H), 2.72 - 3.85 (m, 3H), 5.00 (brs, 1H). IR (neat) ν : 3360 (NH), 2120 (N_3), 1710 (CO). Anal. calcd for $C_8H_{16}N_4O_2$: C, 48.00 ; H, 8.00 ; N, 28.00 ; Found : C, 48.1 ; H, 8.1 ; N, 28.1.

1-(N-methyl, N-tert-butoxycarbonylamino)-2-azidopropane ***10k***

4.00 g of **9k** gave 3.80 g of **10k** . Yd = 83 %. Oil (Rf = 0.5, eluant : hexane/ether, 60/40). ^1H NMR : 1.20 (d, 3H, J = 6.3), 1.45 (s, 9H), 2.92 (s, 3H), 3.08 - 3.95 (m, 3H). IR (neat) ν : 2120 (N_3), 1700 (CO). Anal. calcd for $C_9H_{18}N_4O_2$: C, 50.46 ; H, 8.41 ; N, 26.16 ; Found : C, 50.7 ; H, 8.3 ; N, 26.4.

1-azido-2-(N-tert-butoxycarbonylamino)propane ***10e***

2.80 g of **9e** gave 2.35 g of **10e**. Yd = 73 %. Oil (Rf = 0.5, eluant : hexane/ether, 60/40). ^1H NMR : 1.20 (d, 3H, J = 6.6), 1.45 (s, 9H), 3.25 - 3.45 (m, 2H), 3.58 - 4.12 (m, 1H), 4.67 (brs, 1H). IR (neat) ν : 3350 (NH), 2110 (N_3), 1700 (CO). Anal. calcd for $C_8H_{16}N_4O_2$: C, 48.00 ; H, 8.00 ; N, 28.00 ; Found : C, 47.7 ; H, 8.2 ; N, 28.6.

1-azido-2-(N-tert-butoxycarbonylamino)butane ***10l***

1.50 g of **9l** gave 1.40 g of **10l**. Yd = 82 %. Oil (Rf = 0.6, eluant : hexane/ether, 60/40). ^1H NMR : 0.95 (t, 3H, J = 7.4), 1.35-1.66 (m, 2H), 1.45 (s, 9H), 3.33 - 3.46 (m, 2H), 3.53 - 3.72 (m, 1H), 4.55 (brs, 1H). IR (neat) ν : 3350 (NH), 2100 (N_3), 1690 (CO). Anal. calcd for $C_9H_{18}N_4O_2$: C, 50.46 ; H, 8.41 ; N, 26.16 ; Found : C, 50.6 ; H, 8.4 ; N, 25.1.

1-azido-2-phenyl-2-(N-tert-butoxycarbonylamino)ethane ***10m***

5.62 g of **9m** gave 4.53 g of **10m**. Yd = 73 %. mp = 88°C (Rf = 0.5, eluant : hexane/ether, 75/25). ^1H NMR : 1.42 (s, 9H), 3.60 (d, 2H, J = 5.4), 4.85 (dt, 1H, J = 5.4 and 7.8), 5.12 (brd, 1H, J = 7.8), 7.20 - 7.48 (m, 5H). IR (neat) ν : 3400 (NH), 2100 (N_3), 1690 (CO). Anal. calcd for $C_{13}H_{18}N_4O_2$: C, 59.54 ; H, 6.87 ; N, 21.37 ; Found : C, 59.4 ; H, 7.0 ; N, 21.3.

1-azido-1-phenyl-2-(N-tert-butoxycarbonylamino)ethane ***10n***

5.50 g of **9n** gave 3.64 g of **10n**. Yd = 60 %. mp = 72°C (Rf = 0.4, eluant : hexane/ether, 75/25). ^1H NMR : 1.45 (s, 9H), 3.23 (ddd, 1H, J = 5.3, 6.8 and 14.2), 3.46 (ddd, 1H, J = 6.0, 8.3 and 14.2), 4.67 (dd, 1H, J = 5.3 and 8.3), 7.31 - 7.42 (m, 5H). IR (Nujol) ν : 3380 (NH), 2095 (N_3), 1670 (CO). Anal. calcd for $C_{18}H_{18}N_4O_2$: C, 59.54 ; H, 6.87 ; N, 21.37 ; Found : C, 59.5 ; H, 6.9 ; N, 21.4.

Synthesis of 1,2-aminoazides hydrochlorides **1, HCl**

The solution of N-protected aminoazide **10** (10 mmoles) in ethylacetate (50 ml) was saturated with gaseous hydrochloric acid and set aside overnight at room temperature. The solvent was then evaporated, the residue diluted with ether (30 ml) and refrigerated. The precipitated crystals were filtered off, washed with ether and dried under vacuum.

1-amino-2-azidopropane hydrochloride ***1d, HCl***

1.00 g of **10d** gave 490 mg of **1d**, HCl.(picrate, mp = 143°C) Yd = 72 %. ^{1}H NMR (D_2O) : 1.31 (d, 3H, J = 6.6), 2.87 (dd, 1H, J = 9.5 and 13.3), 3.07 (dd, 1H, J = 3.6 and 13.3), 3.85 - 3.94 (m, J = 3.6, 6.6 and 9.5). ^{13}C NMR (D_2O) : 18.5, 46.1, 57.2. IR (Nujol) ν : 2110 (N_3).Anal. calcd for $C_3H_8N_4$, $C_6H_3N_3O_7$ (picrate) : C, 32.82 ; H, 3.34 ; N, 29.78 ; Found : C, 32.9 ; H, 3.3 ; N, 29.4.

1-(N-methylamino)-2-azidopropane hydrochloride ***1k, HCl***

1.48 g of **10k** gave 814 mg of **1k**, HCl. Yd = 78 %. mp = 134°C. ^{1}H NMR (D_2O) : 1.35 (d, 3H, J = 6.6), 2.72 (s, 3H), 3.01 (dd, 1H, J = 9.8 and 13.1), 3.14 (dd, 1H, J = 3.4 and 13.1), 3.94 - 4.05 (m, 1H, J = 3.4, 6.6 and 9.8). ^{13}C NMR (D_2O) : 18.6, 35.7, 50.8, 55.4, 56.2. IR (Nujol) ν : 2120 (N_3). Anal. calcd for $C_4H_{10}N_4$, HCl : C, 31.89 ; H, 7.30 ; N, 37.20 ; Found : C, 31.7 ; H, 7.6 ; N, 37.0.

1-azido-2-aminopropane hydrochloride ***1e, HCl***

2.00 g of **10e** gave 756 mg of **1e**, HCl. Yd = 76 %.(picrate, mp = 134°C) ^{1}H NMR (D_2O) : 1.33 (d, 3H, J = 6.1), 3.52 - 3.81 (m, 3H). ^{13}C NMR (D_2O) : 17.9, 49.7, 55.8. IR (Nujol) ν : 2110 (N_3). Anal. calcd for $C_3H_8N_4$, $C_6H_3N_3O_7$ (picrate): C, 32.82 ; H, 3.34 ; N, 29.78 ; Found : C, 32.6 ; H, 3.3 ; N, 29.4.

1-azido-2-aminobutane hydrochloride ***1l, HCl***

750 mg of **10l** gave 380 mg of **1l**, HCl. Yd = 72 %. mp = 154°C. ^{1}H NMR (D_2O) : 0.87 (t, 3H, J = 7.3), 1.60 (q, 2H, J = 7.3), 3.26 (dq, 1H, J = 3.6 and 7.3), 3.50 (dd, 1H, J = 7.4 and 13.4), 3.71 (dd, 1H, J = 3.6 and 13.4). ^{13}C NMR (D_2O) : 11.5, 25.5, 53.8, 54.8. IR (Nujol) ν : 2110 (N_3). Anal. calcd for $C_4H_{10}N_4$, HCl : C, 31.89 ; H, 7.30 ; N, 37.20 ; Found : C, 31.7 ; H, 7.3 ; N, 37.3.

1-azido-2-phenyl-2-aminoethane hydrochloride ***1m, HCl***

632 mg of **10m** gave 473 mg of **1m**, HCl. Yd = 98 %. mp = 132°C. ^{1}H NMR (D_2O) : 3.82 (dd, 1H, J = 7.8 and 13.3), 3.87 (dd, 1H, J = 5.2 and 13.3), 4.54 (dd, 1H, J = 5.2 and 7.8), 7.39 - 7.48 (m, 5H). ^{13}C NMR (D_2O) : 55.5, 56.6, 129.5, 131.9, 132.3, 136.0 IR (Nujol) ν : 2110 (N_3). Anal. calcd for $C_8H_{10}N_4$, HCl : C, 48.36 ; H, 5.54 ; N, 28.21 ; Found : C, 48.1 ; H, 5.5 ; N, 27.9.

1-azido-1-phenyl-2-aminoethane hydrochloride ***10n, HCl***

1.35 g of **10n** gave 945 mg of **10n**, HCl. Yd = 92 %. mp = 192°C. ^{1}H NMR (D_2O) : 3.24 (d, 2H, J = 7.3), 4.98 (t, 1H, J = 7.3), 7.44 - 7.49 (m, 5H). ^{13}C NMR (D_2O) : 46.0, 64.8, 129.8, 131.9, 132.1, 137.5. IR (Nujol) ν : 2120 (N_3). Anal. calcd for $C_8H_{10}N_4$, HCl : C, 48.36 ; H, 5.54 ; N, 28.21 ; Found : C, 48.5 ; H, 5.7 ; N, 27.6.

I.d - Synthesis of 1,2-diamine dihydrochloride 11, 2 HCl from 1,2-aminoazides 1

General procedure :

A solution of the aminoazide **1** (3 mmoles) in ethanol (10 ml) and HCl 12 N (1 ml) was hydrogenated over 10 % palladium on charcoal (50 mg) at 60 psi hydrogen in a Parr hydrogenation apparatus for 18 h at room temperature. The catalyst was separated by filtration and the solvent was evaporated under reduced pressure. The residue was washed with ether (30 ml) and filtered to give a solid used for characterisation without further purification.

1,2-diaminopropane dihydrochloride

300 mg of **1** gave 430 mg. Yd = 97 %. mp = 236 - 238°C.^{1}H NMR (D_2O) : 1.44 (d, 3H, J = 6.8), 3.25 (dd, 1H, J = 7.0 and 13.5), 3.39 (dd, 1H, J = 6.1 and 13.5), 3.71 - 3.82 (m, 1H, J = 6.1, 6.8 and 7.0).^{13}C NMR (D_2O) : 18.3, 44.4, 47.8.

1-phenyl-1,2 diaminoethane dihydrochloride

398 mg of **1** gave 410 mg. Yd = 98 %. mp = 160°C (dec.).^{1}H NMR (D_2O) : 3.62 (dd, 1H, J = 9.8 and 13.1), 3.68 (dd, 1H, J = 5.6 and 13.1), 4.67 (dd, 1H, J = 5.6 and 9.8), 7.47 - 7.55 (m, 5H).^{13}C NMR (D_2O) : 43.6, 54.8, 130.3, 132.5, 133.4, 133.8.Anal. calc. for $C_8H_{14}N_2Cl_2$: C, 45.93 ; H, 6.69 ; N, 13.39 ; Found : C, 45.6 ; H, 6.7 ; N, 12.6.

1-(N-methyl)-1,2-diaminopropane dihydrochloride

345 mg of **1** gave to 354 mg. Yd = 96 %. mp = 178°C.^{1}H NMR (D_2O) : 1.37 (d, 3H, J = 6.7), 2.74 (s, 3H), 3.26 (dd, 1H, J = 7.0 and 13.3), 3.32 (dd, 1H, J = 6.1 and 13.3), 3.74 (m, 1H, J = 6.1, 6.7 and 7.0).^{13}C NMR (D_2O) : 18.4, 36.2, 46.8, 53.6.

1-Phenyl-2-(N-methyl)-1,2 diaminopropane dihydrochloride

650 mg of **1** gave 800 mg. Yd = 98 %. mp = 226°C (dec.).^{1}H NMR (D_2O) : 1.56 (d, 3H, J = 6.7), 2.61 (s, 3H), 3.97 (dq, 1H, J = 6.7 and 9.8), 4.56 (d, 1H, J = 9.8), 7.48 - 7.56 (m, 5H).^{13}C NMR (D_2O) : 15.0, 32.8, 59.0, 59.1, 130.4, 132.8, 133.71, 133.77.Anal. calc. for $C_{10}H_{18}N_2Cl_2$: C, 50.63 ; H, 7.59 ; N, 11.81 ; Found : C, 50.4 ; H, 7.6 ; N, 11.8.

I.e - Synthesis of 1-N- or 2-N-(tert-butoxycarbonyl)-1,2-diaminoalcanes hydrochlorides 13,HCl from N-BOC aminoazides 10

General procedure :

A solution of 4 mmoles of the aminoazide **10** in 50 ml of methanol and 1 ml of chloroform was hydrogenated over 10 % palladium on charcoal (100 mg) at 30 psi hydrogen in a Parr hydrogenation apparatus for 3 h at room temperature. At the end of hydrogenolysis, 0,2 mmole of hydrogen chloride (600 µl of a solution 0,2 N in ether) was added. The reaction mixture was filtered to eliminate the catalyst and the solvent was removed under reduce pressure. The product crystallized spontaneously. It was triturated several times with ether (50 ml) and was isolated by filtration.

2-(N-tert-butoxycarbonyl)-1,2-diaminobutane hydrochloride

280 mg of **9** gave 235 mg. Yd = 80 %. mp = 154-156°C.^{1}H NMR (D_2O) : 0,87 (t, 3H, J = 7.4), 1.40 (s, 9H), 1.49 - 1.62 (m, 2H), 2.87 (dd, 1H, J = 9.8 and 13.1), 3.10 (dd, 1H, J = 4.0 and 13.1), 3.57 - 3.70 (m, 1H, J = 4.0, 7.4 and 9.8).^{13}C NMR (D_2O) : 11.9, 27.7, 30.1, 45.6, 52.9, 83.8, 160.8.IR (Nujol) ν : 3360 (NH), 1680 (CO).

1-(N-tert-butoxycarbonyl)-2-phenyl-1,2-diaminoethane hydrochloride.

760 mg of **9** gave 600 mg. Yd = 76 %. mp = 175°C (dec). ^{1}H NMR (D_2O) : 1.32 (s, 9H), 3.45 - 3.64 (m, 2H), 4.43 (t, 1H, J = 6.7), 7.36 - 7.49 (m, 5H).^{13}C NMR (D_2O) : 30.0 ; 45.7 ; 57.2 ; 83.9 ; 129.6 ; 131.8 ; 132.0 ; 136.5 ; 160.4.IR (Nujol) ν : 3360 (NH), 1670 (CO).

I.f - Synthesis of 1,2-diamine dihydrochloride 12, 2HCl from 1,2-aminoazides 1

General procedure :

To a solution of the aminoazide (4 mmoles) in dry ether (10 ml), were added slowly 6 mmoles of hydrogen chloride (2 ml of a solution 3N in dry ether) which induces the precipitation of the hydrochloride. After 10 minutes, the solvent was evaporated under reduced pressure and methylene chloride (4 ml) was added. To the mixture was added dropwise over 15 minutes a solution of the dichloroborane ($R'BCl_2$) in CH_2Cl_2. The nitrogen evolution started after a few seconds. The reaction mixture was kept at room temperature for 18 h. Addition of 2 ml of anhydrous methanol, followed 10 minutes later by 10 ml of anhydrous ether occasionned the precipitation of white crystals of **12**, 2HCl which were isolated by filtration.

1-(N-cyclohexyl)-1,2-diaminoethane dihydrochloride

258 mg of **1** gave 490 mg. Yd = 89 %. mp = 184°C.^{1}H NMR (D_2O) : 0.95 - 1.98 (m, 10H), 2.90 - 3.24 (m, 5H).Anal. calc. for $C_8H_{20}N_2Cl_2$, H_20 : C, 41.20 ; H, 9.44 ; N, 12.01 ; Found : C, 41.4 ; H, 9.3 ; N, 12.0.

1-(N-phenyl)-1,2-diaminoethane dihydrochloride

300 mg of **1** gave 590 mg. Yd = 81 %. mp = 206°C ^{1}H NMR (D_2O) : 3.10 (t, 2H, J = 6.2), 3.37 (t, 2H, J = 6.2), 6.72 - 6.86 (m, 3H), 7.20 - 7.30 (m, 2H). ^{13}C NMR (D_2O) : 41.1, 44.0, 116.4, 121.2, 132.2, 149.9. Anal. calc. for $C_8H_{14}N_2Cl_2$, 0.5 H_2O : C, 44.03 ; H, 6.88 ; N, 12.84 ; O, 3.66; Found : C, 44.1 ; H, 6.8 ; N, 12.9 ; O, 3.6.

1-(N-hexyl)-1,2-diaminobutane dihydrochloride

456 mg of **1** gave 830 mg. Yd = 85 %. mp = 200-204°C.^{1}H NMR (D_2O) : 0.80 - 0.84 (m, 3H), 0.99 (t, 3H, J = 7.5), 1.20 - 1.38 (m, 6H), 1.61 - 1.87 (m, 4H), 3.00 - 3.13 (m, 2H), 3.27 (dd, 1H, J = 7.1 and 13.8), 3.32 (dd, 1H, J = 5.3 and 13.8), 3.47 - 3.61 (m, 1H, J = 5.3, 7.1 and 7.5).^{13}C NMR (D_2O) : 11.0, 15.8, 24.2, 26.3, 27.8, 27.9, 32.9, 51.0, 51.3, 52.4.

1-(N-hexyl)-2-(N'-methyl)-1,2-diaminoethane dihydrochloride

350 mg of **1** gave 640 mg. Yd = 79 %. mp = 268 - 270°C.^{1}H NMR (D_2O) : 0.78 - 0.83 (m, 3H), 1.22 - 1.37 (m, 6H), 1.65 (quint., 2H, J = 7.4), 2.76 (s, 3H), 3.07 (t, 2H, J = 7.6), 3.37 - 3.42 (m, 4H). ^{13}C NMR (D_2O) : 15.8, 24.2, 27.7, 27.9, 32.9, 35.8, 45.4, 46.9, 50.9. Anal. calc. for $C_9H_{24}N_2Cl_2$: C, 46.75 ; H, 10.38 ; N, 12.12 ; Found : C, 46.7 ; H, 10.4 ; N, 12.2.

1-(N-methyl)-2-(N'-phenyl)-1,2-diaminoethane dihydrochloride

300 mg of **1** gave 546 mg. Yd = 81 %. mp = 170°C.^{1}H NMR (D_2O) :2.67 (s, 3H), 3.28 - 3.53 (m, 2H), 3.58 - 3.92 (m, 2H), 7.45 - 7.53 (m, 5H). :Anal. calc. for $C_9H_{15}N_2Cl$: C, 57.90 ; H, 8.04 ; N, 15.01 ; Found :C, 57.9 ; H, 8.0 ; N, 15.1

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