HETEROCYCLES, Vol. 68, No. 4, 2006, pp. 701 - 712. © The Japan Institute of Heterocyclic Chemistry
Received, 6th January, 2006, Accepted, 9th March, 2006, Published online, 10th March, 2006. COM-06-10667

1,3-DIBROMO-5,5-DIMETHYLHYDANTOIN AS A NEW IMIDAZOLIDINE DEHYDROGENATING AGENT: SYNTHESIS OF 4,5-DIHYDRO-1*H*-IMIDAZOLIUM SALTS

María C. Caterina, María A. Figueroa, Isabel A. Perillo, and Alejandra Salerno*

Department of Organic Chemistry, Faculty of Pharmacy and Biochemistry, University of Buenos Aires. Junín 956 (1113) Buenos Aires, Argentina. E-mail: asalerno@ffyb.uba.ar

Abstract – A study about the scope of the method for the attainment of 4,5-dihydro-1*H*-imidazolium salts by dehydrogenation of *N*,*N*´-dibenzyl- and *N*-aryl-*N*´-benzylimidazolidines is presented. Employed dehydrogenating agents were *N*-bromoacetamide (NBA), *N*-bromosuccinimide (NBS), carbon tetrachloride and 1,3-dibromo-5,5-dimethylhydantoin (DBDMH). DBDMH was the choice reagent due to the purity of the attained products, lowest reaction times and highest yields.

INTRODUCTION

4,5-Dihydro-1*H*-imidazolium salts with different types of substitution have been used as suitable models of the coenzyme N^5,N^{10}-methenyltetrahydrofolic acid, promoting biochemical transfer of one carbon unit at the oxidation level of formic acid.[1-3] Thus, in attempts to mimic the biological process chemically reproducing the transfer of C-2, reactions of various *N*,*N*´-disubstituted salts with suitable nucleophilic reagents have been studied.[4] Furthemore, the value of 4,5-dihydro-1*H*-imidazolium salts as synthetic precursors has been demonstrated.[4c,4d,5-8] Additionally, 4,5-dihydro-1*H*-imidazolium salts have been studied owing to their surfactant activity[9] and employed in various metal-catalysed reactions[10] and as catalysts in the opening of epoxides.[11]

Attainment of 4,5-dihydro-1*H*-imidazolium salts has been developed by different synthetic routes, depending on the required substitution pattern. Thus, *N*-alkyl substituted salts were classically synthesized by quaternization of the corresponding 4,5-dihydro-1*H*-imidazole.[8] The method is limited by the precursor imidazole synthesis and the nature of the alkylating agent determined by the mechanism, a typically S_N2

pathway. Reaction of electron-rich alkenes (bisimidazolidinylidene derivatives) in acid media[12] and the *N*-formyl-*N,N´*-diarylethylenediamines cyclization,[13] have been employed to the attainment of 2-unsubstituted 1,3-diaryl-4,5-dihydro-1*H*-imidazolium salts. On the other hand, synthesis of *N,N´*-disubstituted salts by cyclocondensation of *N,N´*-dialkylethylenediamines with carboxylic acids and derivatives has been little studied.[14,15]

Synthesis of 4,5-dihydro-1*H*-imidazolium salts by dehydrogenation of imidazolidines results a highly attractive method due to the easy preparation of precursor aminals by condensation of aldehydes with properly substituted ethylenediamines.[16] The synthesis of 1,3-diaryl- and 1,2-diaryl-3-alkyldihydro-imidazolium salts with NBA, NBS and carbon tetrachloride among other dehydrogenating agents has been previously studied by us.[17]

Continuing ongoing research on the synthesis and study of 4,5-dihydro-1*H*-imidazolium salts[5-7,17] we present in this work the synthesis of a series of *N*-benzyl- and *N,N´*-dibenzyl-4,5-dihydro-1*H*-imidazolium salts (**1**) by dehydrogenation of the corresponding imidazolidines (**2**) (Scheme 1)**.** In order to determine the scope of application of the method, reactions of compounds (**2a-u**) with the reagents mentioned above as well as with 1,3-dibromo-5,5-dimethylhydantoin (DBDMH, a *N*-haloamide closely related to NBS and NBA) were assayed.

RESULTS AND DISCUSSION

Precursor imidazolidines (**2**) were easily obtained by condensation of *N*-aryl-*N´*-benzylethylenediamines (**3,** R_1=Ar, R_3=Bn) and *N,N´*-dibenzylethylenediamines (**3,** R_1=R_3=Bn) with aldehydes in ethanol under reflux. Synthesis of compounds (**3**) had been previously optimized by us by reaction of ethylenediamine or *N*-arylethylenediamines with benzaldehydes promoted by microwave irradiation, and further reduction of the formed imines.[18]

Scheme 1

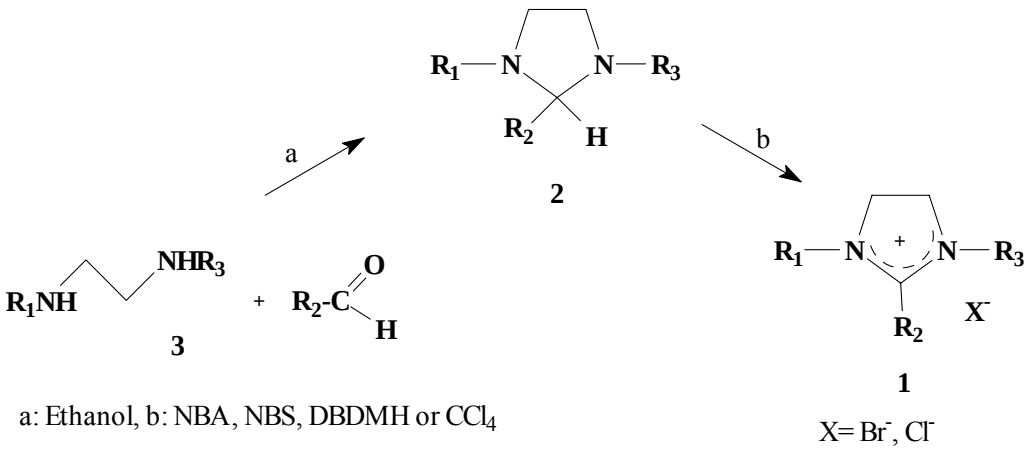


Table 1: 4,5-Dihydro-1*H*-imidazolium salts (**1**), imidazolidines (**2**) and ethylenediamines (**3**)

Compounds **1,2,3**	R_1	R_2	R_3
a	$C_6H_5CH_2$	H	$C_6H_5CH_2$
b	4-$CH_3OC_6H_4CH_2$	H	4-$CH_3OC_6H_4CH_2$
c	4-$ClC_6H_4CH_2$	H	4-$ClC_6H_4CH_2$
d	3,4-$Cl_2C_6H_3CH_2$	H	3,4-$Cl_2C_6H_3CH_2$
e	4-$CH_3OC_6H_4CH_2$	CH_3	4-$CH_3OC_6H_4CH_2$
f	$C_6H_5CH_2$	C_6H_5	$C_6H_5CH_2$
g	4-$CH_3OC_6H_4CH_2$	C_6H_5	4-$CH_3OC_6H_4CH_2$
h	4-$ClC_6H_4CH_2$	C_6H_5	4-$ClC_6H_4CH_2$
i	3,4-$Cl_2C_6H_3CH_2$	C_6H_5	3,4-$Cl_2C_6H_3CH_2$
j	4-$ClC_6H_4CH_2$	4-ClC_6H_4	4-$ClC_6H_4CH_2$
k	4-$ClC_6H_4CH_2$	4-$CH_3OC_6H_4$	4-$ClC_6H_4CH_2$
l	4-$ClC_6H_4CH_2$	3,4-$Cl_2C_6H_3$	4-$ClC_6H_4CH_2$
m	4-$ClC_6H_4CH_2$	3-ClC_6H_4	4-$ClC_6H_4CH_2$
n	4-$CH_3C_6H_4$	H	$C_6H_5CH_2$
o	4-ClC_6H_4	H	$C_6H_5CH_2$
p	4-$NO_2C_6H_4$	H	$C_6H_5CH_2$
q	4-$CH_3OC_6H_4$	H	$C_6H_5CH_2$
r	4-$CH_3C_6H_4$	C_6H_5	$C_6H_5CH_2$
s	4-ClC_6H_4	C_6H_5	$C_6H_5CH_2$
t	4-$NO_2C_6H_4$	C_6H_5	$C_6H_5CH_2$
u	4-$CH_3OC_6H_4$	C_6H_5	$C_6H_5CH_2$

Dehydrogenations of **2** with NBS, NBA and DBDMH were carried out at room temperature by stirring a mixture of the imidazolidine and the oxidant in THF. In this medium, salts generally precipitated as long as they were formed; otherwise precipitation was induced by adding ether. NBS and NBA promoted dehydrogenation of 2-unsubstituted *N*,*N*´-dibenzylimidazolidines (**2a-d**) in times which varied between 1 and 3 h, with yields of 50-70%, being in general highest with NBA (Table 2). For the C-2 substituted imidazolidines (**2e-m**) reaction times increased to 2-5 h and yields decreased in approximately a 10%.

For unsymmetrically *N*,*N*´-disubstituted imidazolidines (**2n-u**), reaction yields decreased with both reagents to 30-40% and reaction times varied between 4.5-5 h for 2-unsubstituted compounds (**2n-q**) and increased up to 6-6.5 h for 2-phenyl substituted compounds (**2r-u**).

Reactions with carbon tetrachloride were carried out by refluxing solution of imidazolidines. Reaction times varied between 2-8 h. The prolonged heating promoted the formation of by-products and/or decomposition of the desired compounds, so as product purity and reaction yields strongly diminished in comparison with the above *N*-haloamides.

Reactions with DBDMH were carried out in the same conditions as those with NBS and NBA. In all cases, dehydrogenation of imidazolidines (**2a-u**) with DBDMH occurred in a much faster rate than with the other reagents and requires under 5 min for imidazolidines (**2a-m**) (1,3-dibenzyl) and under 15 min for the rest of compounds. Reaction yields increased to 60-70 % in the synthesis of salts (**1n-u**) and to 70-90% for the synthesis of *N,N´*-symmetrically substituted compounds (**2a-m**).

Table 2: Summary of dehydrogenations (**2→1**) using, NBA, NBS, DBDMH and CCl_4

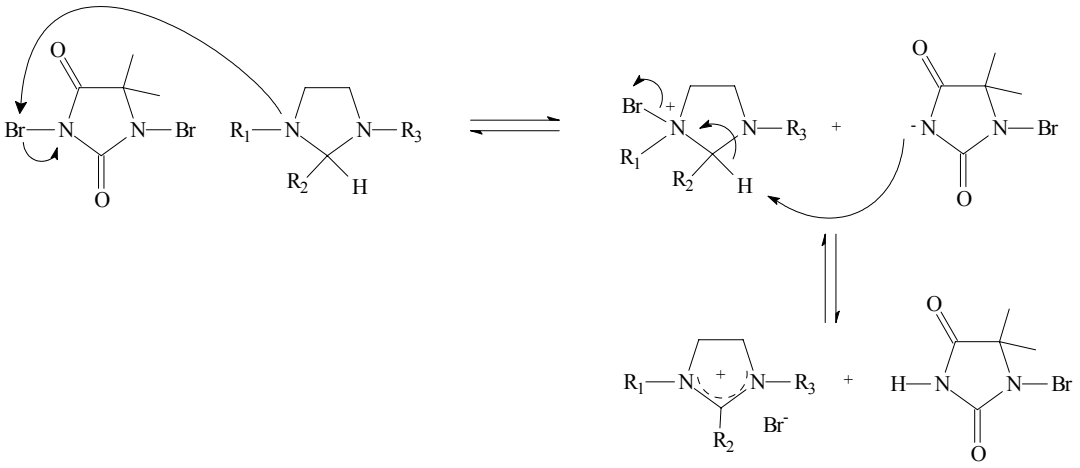
substrate	NBA		NBS		DBDMH		CCl_4	
	Time (h)	Yield (%)	Time (h)	Yield (%)	Time (min)	Yield (%)	Time (h)	Yield (%)
2a	1.5	68	2.5	57	2	89	2	38
2b	1.5	70	2	55	2	86	2.5	38
2c	1	69	2	52	1	78	3	32
2d	2	65	3	50	1	77	4	21
2e	3	60	4	45	4	85	7	30
2f	2.5	59	3	50	3	87	6	35
2g	2.5	55	2.5	47	4	78	6	25
2h	3.5	58	4	43	3	85	7.5	25
2i	3.5	57	4.5	49	2	88	5.5	30
2j	4.2	52	5	40	4	85	8	32
2k	3.5	59	4	41	3	86	6.5	30
2l	3	55	4.5	50	2	79	4	29
2m	3	59	4	45	2	87	6.5	29
2n	4	32	4.5	30	8	65	6.5	22
2o	4.5	40	5	35	7	63	6	22
2p	4.5	38	5	31	12	69	6.5	19
2q	4.5	39	5	31	10	68	5	20
2r	5.5	37	6	32	10	69	7	25
2s	6	39	6.6	34	15	64	7.5	20
2t	6.5	37	6.5	30	8	66	6.5	23
2u	6	36	6.5	30	10	65	6.5	21

Although dehydrogenation process could theoretically continue until reaching the aromatic imidazolium salt, no secondary product with these features was observed in the studied cases.

In order to determine if reaction with DBDMH occurs by a ionic or radical mechanism, as it was proposed for other *N*-haloamides, reactions were repeated in the same conditions but with a radical promoting reagent (benzoyl peroxide) and a radical inhibitor (BHT). In both cases yields and reaction times did not

vary. Thus, a ionic mechanism is proposed, which probably involves bromination of imidazolidine nitrogen followed by deprotonation and displacement of a bromide anion.

Scheme 2



Melting points and spectroscopic data of compounds (**1a-u**) are given in Table 3**.** As it arose from structural and physical features *N*-aryl-*N'*-benzyldihydroimidazolium salts (**1n-u**), belong to a new family of ionic liquids.[19]

Table 3: Data for products (**1a-u**) (X=Br)

Product	mp (ºC)	^{1}H NMR (DMSO-d_6/TMS). δ, *J* (Hz)
1a	163-165	8.95 (s, 1 H, NCHN), 7.45-7.35 (m, 10 H, aromatics), 4.70 (s, 4 H, CH_2), 3.89 (s, 4 H, CH_2-CH_2)
1b	172-174	10.17 (s, 1 H, NCHN), 7.30 (d, 4 H, aromatics , *J*=8.6), 6.89 (d, 4 H, aromatics, *J*=8.6), 4.76 (s, 4 H, CH_2), 3.78 (s, 6 H, CH_3), 3.68 (s, 4 H, CH_2-CH_2)
1c	190-192	8.79 (s, 1H, NCHN), 7.45 (d, 4 H, aromatics, *J*=8.1), 7.40 (d, 4 H, aromatics., *J*=8.1),4.61 (s, 4 H, CH_2), 3.70 (s, 4H, CH_2-CH_2)
1d	158-160	8.70 (s, 1 H, NCHN), 7.70-7.85 (m, 4 H, aromatics), 7.45-7.50 (m, 2 H, aromatics), 4.66 (s, 4 H, CH_2), 3.72 (s, 4 H, CH_2-CH_2)
1e	hygroscopic	7.26 (d, 4 H, aromatics, *J*=8.5), 6.90 (d, 4 H, aromatics, *J*=8.5), 4,72 (s, 4 H, CH_2), 3.90 (s, 4 H, CH_2-CH_2), 3.80 (s, 6 H, OCH_3), 2.60 (s, 3 H, CH_3)
1f[20]	165-167	7.72-7.60 (m, 5 H, aromatics), 7.31-7.39 (m, 10 H, aromatics), 4.40 (s, 4 H, CH_2), 3.89 (s, 4 H, CH_2-CH_2)
1g	hygroscopic	7.90 (dd, 2 H, aromatics., J_1=7.2, J_2=2.0), 7.63-7.65 (m, 3 H, aromatics), 7.10 (d, 4 H, aromatics, *J*=8.1), 6.81 (d, 4 H, aromatics, *J*=8.1), 4.42 (s, 4 H, CH_2), 4.02 (s, 4 H, CH_2-CH_2), 3.73 (s, 6 H, CH_3)
1h	180-182	7.80-7.69 (m, 5 H, aromatics), 7.47 (d, 4 H, aromatics, *J*=8.2), 7.35 (d, 4 H, aromatics, *J*=8.2), 4.38 (s, 4 H, CH_2), 3.87 (s, 4 H, CH_2-CH_2)

1i	198-199	7.70-7.60 (m, 9 H, aromatics), 7.40 (s, 2 H, aromatics), 4.42 (s, 4 H, CH_2), 3.92 (s, 4H, CH_2-CH_2)
1j	173-174	7.79 (d, 2 H, aromatics, *J*=8.9), 7.72 (d, 2 H, aromatics, *J*=8.9), 7.46 (d, 4 H, aromatics, *J*=8.3), 7.38 (d, 4 H, aromatics, *J*=8.3), 4.40 (s, 4 H, CH_2), 3.88 (4 H, CH_2-CH_2)
1k	167-169	7.61 (d, 2 H, aromatics, *J*=9.1), 7.46 (d, 4H, aromatics, *J*=8.5), 7.36 (d, 4H, aromatics, *J*=8.5), 7.21 (d, 2 H, aromatics, *J*=9.1), 4.45 (s, 4 H, CH_2), 3.87 (s, 4 H, CH_2-CH_2), 3.81 (s, 3 H, CH_3)
1l	192-194	7.90-8.10 (m, 2 H, aromatics), 7.60-7.70 (m, 1 H, aromatics), 7.45 (d, 4 H, aromatics, *J*=9.1), 7.34 (d, 4 H, aromatics, *J*=9.1), 4.41 (s, 4 H, CH_2), 3.87 (s, 4 H, CH_2-CH_2)
1m	119-120	7.90-7.60 (m, 4 H, aromatics), 7.37 (d, 4 H, aromatics., *J*=8.3), 7.19 (d, 4 H, aromatics, *J*=8.3), 4.60 (s, 4 H, CH_2), 4.15-4.00 (m, 4 H, CH_2-CH_2)
1n	oil	9.75 (s, 1 H, NCHN), 7.60-7.30 (m, 9 H, aromatics), 5.22 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.42-4.30 (m, 2 H, CH_2N), 3.85-3.70 (m, 2 H, CH_2N), 2.10 (s, 3 H, CH_3)
1o	210	11.3 (s, 1 H, NCHN), 7.60-7.20 (m, 9 H, aromatics), 5.20 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.35 (bs, 2 H, CH_2N), 4.10 (bs, 2 H, CH_2N)
1p	oil	9.85 (s, 1 H, NCHN), 8.39 (d, 2 H, aromatics, *J*=9.1), 7.56 (d, 2 H, aromatics, *J*=9.1), 7.50-7.30 (m, 5 H, aromatics), 4.88 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.40 (t, 2 H, CH_2N, *J*=9.0), 3.90 (t, 2 H, CH_2N, *J*=9.0)
1q	oil	9.70 (s, 1 H, NCHN), 7.60-7.30 (m, 9 H, aromatics), 5.00 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.32 (m, 2 H, CH_2N), 3.80 (m, 2 H, CH_2N), 3.64 (s, 3 H, OCH_3)
1r	oil	7.65-7.50 (m, 4 H, aromatics), 7.48-7.30 (m, 6 H, aromatics), 7.20-7.05 (m, 4 H, aromatics), 4.52 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.44 (t, 2 H, *J*=9.8, CH_2N), 4.04 (t, 2 H, *J*=9.8, CH_2N), 2.20 (s, 3 H, CH_3)
1s	oil	7.65-7.20 (m, 14 H aromatics), 4.75 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.55(t, 2 H, CH_2N, *J*= 10.0), 4.27(t, 2 H, CH_2N, *J*= 10.0)
1t	oil	8.10-7.20 (m, 14 H aromatics), 4.75 (s, 2 H, C*H*$_2$C$_6$H$_5$), 4.65 (t, 2 H, CH_2N, *J*= 9.3), 4.37 (t, 2 H, CH_2N, *J*= 9.3)
1u	oil	7.70-7.52 (m, 5 H aromatics), 7.47-7.32 (m, 5 H aromatics), 7.26 (dd, 2 H aromatics., J_1=6.9, J_2= 1.8), 6.88 (dd, 2 H aromatics., J_1=6.9, J_2= 1.8), 4.53 (s, 2 H, $CH_2C_6H_5$), 4.41 (t, 2 H, CH_2N, *J*=9.7), 4.04 (t, 2 H, CH_2N, *J*=9.7), 3.67 (s, 3 H, OCH_3)

In summary, DBDMH was the choice reagent for *N*-benzyl-*N*´-aryl- and *N*,*N*´-dibenzylimidazolidine dehydrogenation. The method is operationally simple, with very low reaction times, easy work-up procedure and high reaction yields, also being the reagent a cheap commercially available chemical.

EXPERIMENTAL

Melting points were determined with a Büchi capillary apparatus and are uncorrected. ^{1}H NMR spectra were recorded on a Bruker MSL 300 MHz spectrometer using DMSO-d_6. Standard Concentration of the samples was 20 mg/mL. Chemical shifts are reported in ppm (δ) relative to TMS as an internal standard. D_2O was employed to confirm exchangeable protons (ex). MS (EI) were recorded with a GC-MS Shimadzu QP-1000 spectrometer operating at 20 eV. TLC analyses were carried out on aluminium sheets silica gel 60 F_{254} using benzene-methanol (9:1) as the solvent. Column chromatography was performed on silica gel 60 (0.063-0.200 mesh) with typically 30-50 g of stationary phase per gram substance.

N,N´-Disubstituted ethylenediamines (**3**).

Compounds (**3a,b,c,o,p,q**[18] and **3d**)[21] were prepared following literature procedure.[18] The physical data and elemental analyses of the new compounds are as follows:

N-Benzyl-*N´*-4(methylphenyl)ethylenediamine (3n)

Yield: 60%. ^{1}H NMR: δ= 7.50-7.20 (m, 9 H, aromatics), 3.81 (s, 2 H, C*H*$_2$Ar), 3.25 (t, *J*=6.1 Hz, 2 H, C*H*$_2$NAr,), 2.85 (t, *J*=6.1 Hz, 2 H, C*H*$_2$NBn,), 2.30 (s, 3 H, CH_3), 1.90 (bs, 1 H, NH). MS: *m/z*= 240 ($M^{+\cdot}$). Anal. Calcd. for $C_{16}H_{20}N_2$: C, 79.96; H, 8.39, N, 11.66. Found: C, 79.89; H, 8.37; N, 11.68.

Imidazolidines (2).

Compounds (**2**) were obtained by reaction of the corresponding *N,N'*-disubstituted ethylenediamines (**3**) and aldehydes in ethanol.[16] Compounds (**2a,**[22] **2b,g,e**,[16] **2f,**[23] **2h,i.j,**[24] **2m,**[18] **2o**,[25] **2p,**[25] **2s,**[26] **2t**,[18]) were previously described in the literature. The physical data and elemental analyses of the new compounds are as follows.

1,3-Di-(4-chlorobenzyl)imidazolidine (2c)

Yield: 81%. mp: 173-175ºC (ethanol). ^{1}H NMR: δ= 7.15 (d, *J*= 6.7 Hz, 4 H, aromatics), 7.10 (d, *J*=6.7 Hz, 4 H, aromatics), 3.64 (s, 4 H, CH_2Ar), 3.36 (s, 2 H, NCH_2N), 2.80 (s, 4 H, CH_2N). MS: *m/z*= 320 (32%), $M^{+\cdot}$; 322 (20%), $(M+2)^{+\cdot}$. Anal. Calcd for $C_{17}H_{18}N_2Cl_2$: C; 63.56, H; 5.62, N; 8.72. Found: C; 63.62, H; 5.60, N; 8.70.

1,3-Di-(3,4-dichlorobenzyl)imidazolidine (2d)

Yield: 83%. mp: 158-160ºC (ethanol). ^{1}H NMR: δ= 7.50 (s, 2 H, aromatics), 7.34-7.45 (m, 2 H, aromatics), 7.15-7.18 (dd, J_1= 8.0 Hz, J_2= 1.9 Hz, 2 H, aromatics), 3.64 (s, 4 H, CH_2Ar), 3.37 (s, 2 H, NCH_2N), 2.82 (s, 4 H, CH_2N). MS: *m/z*= 388 (42%), $M^{+\cdot}$; 390 (56%), $(M+2)^{+\cdot}$; 392 (27%), $(M+4)^{+\cdot}$. Anal. Calcd for $C_{17}H_{16}N_2Cl_4$: C; 52.34, H; 4.13, N; 7.18. Found: C; 52.30, H; 4.15, N; 7.16.

1,3-Di-(3,4-dichlorobenzyl)-2-phenylimidazolidine (2i)

Yield: 78%. mp: 81-83ºC (ethanol). ^{1}H NMR: δ= 7.59-7.56 (m, 2 H, aromatics), 7.43-7.25 (m, 7 H, aromatics), 7.06 (dd, J_1= 8.1 Hz, J_2= 1.6 Hz, 2 H, aromatics), 3.81 (s, 1 H, NCHN), 3.68 (d, *J*=13.3 Hz, 2 H, CH_2Ar,), 3.21-3.10 (m, 4 H, CH_2Ar and CH_2N), 2.49-2.44 (m, 2 H, CH_2N). MS: *m/z*= 464 (35%), $M^{+\cdot}$; 466 (44%), $(M+2)^{+\cdot}$; 468 (23%), $(M+4)^{+\cdot}$. Anal. Calcd for $C_{23}H_{20}N_2Cl_4$: C, 59.25; H, 4.32; N, 6.01. Found: C; 59.32, H; 4.30, N; 5.99.

1,3-Di-(4-chlorobenzyl)-2-(4-metoxyphenyl)imidazolidine (2k)

Yield: 83%. mp: 110-111ºC (ethanol). ^{1}H NMR: δ= 7.5 (dd, J_1=6.7 Hz, J_2=2.1 Hz, 2 H, aromatics), 7.30-7.15 (m, 8 H, aromatics), 6.91 (dd, J_1=6.7 Hz, J_2=2.1 Hz , 2 H, aromatics), 3.89 (s, 1 H, NCHN), 3.82 (s, 3 H, OCH_3), 3.89 (d, *J*=13.8, 2 H, CH*H*Ar), 3.20-3.05 (m, 4 H, CH*H*Ar, CH_2N), 2.43 (m, 2 H, CH_2N). MS: *m/z*=426 (38%), $M^{+\cdot}$; 428 (25%), $(M+2)^{+\cdot}$. Anal. Calcd for $C_{24}H_{24}N_2OCl_2$: C; 67.45, H; 5.66, N; 6.55. Found: C; 67.56, H; 5.68, N; 6.56.

1-Benzyl-3-(4-methylphenyl)imidazolidine (2n)

Yield: 74%. mp: 67-69ºC (ethanol). ^{1}H NMR: δ= 7.41-7.32 (m, 5 H, aromatics), 7.02 (dd, J_1= 6.6 Hz, J_2= 2.0 Hz, 2 H, aromatics), 6.40 (dd, J_1= 6.6 Hz, J_2= 2.0 Hz, 2 H, aromatics), 3.99 (s, 2 H, NCH_2N), 3.77 (s, 2 H, CH_2Ar), 3.42 (t, *J*=6.4 Hz, 2 H CH_2NAr,), 3.02 (t, *J*= 6.4 Hz, 2 H, CH_2NBn), 2.25 (s, 3 H, CH_3). MS: *m/z*= 252 ($M^{+\cdot}$). Anal. Calcd for $C_{17}H_{20}N_2$: C; 80.91, H; 7.99, N; 11.10. Found: C; 80.86, H; 8.01, N; 11.14.

1-Benzyl-3-(4-methoxyphenyl)imidazolidine (2q)

Yield: 74%. mp: 78-80ºC (ethanol). ^{1}H NMR: δ= 7.32-7.28 (m, 5 H, aromatics), 6.90 (d, *J*=8.6 Hz, 2 H, aromatics), 6.43 (d, *J*=8.6 Hz, 2 H, aromatics), 3.80 (s, 2 H, NCH_2N), 3.78 (s, 3 H, OCH_3), 3.67 (s, 2 H, CH_2Ar), 3.40 (t, *J*= 6.2 Hz, 2 H CH_2NAr,), 3.01 (t, *J*=6.2 Hz, 2 H, CH_2NBn). MS: *m/z*= 268 ($M^{+\cdot}$). Anal. Calcd for $C_{17}H_{20}N_2O$: C; 76.09, H; 7.51, N; 10.44. Found: C; 76.15, H; 7.53, N; 10.47.

1-Benzyl-3-(4-methylphenyl)-2-phenylimidazolidine (2r)

Yield: 72%. mp: 113-114ºC (ethanol). ^{1}H NMR: δ= 7.36-7.23 (m, 10 H, aromatics), 6.94 (d, *J*= 8.6 Hz, 2 H, aromatics), 6.41 (d, *J*= 8.6 Hz, 2 H, aromatics), 5.01 (s, 1 H, NCHN), 3.75 (d, 1 H, *J*= 12.9 Hz, C*H*HAr), 3.52 (d, 1 H, *J*= 12.9 Hz, C*H*HAr), 3.22-3.14 (m, 2 H, CH_2NAr), 2.91-2.85 (m, 2 H, CH_2NBn), 2.20 (s, 3 H, CH_3). MS: *m/z*= 328 ($M^{+\cdot}$). Anal. Calcd for $C_{23}H_{24}N_2$: C; 84.11, H; 7.36, N; 8.53. Found: C; 84.20, H; 7.34, N; 8.56.

1-Benzyl-3-(4-methoxyphenyl)-2-phenylimidazolidine (2u)

Yield: 78%. mp: 101-103ºC (ethanol). ^{1}H NMR: δ= 7.40-7.20 (m, 10 H, aromatics), 6.74 (dd, J_1=6.9 Hz, J_2= 2.3 Hz, 2 H, aromatics), 6.44 (dd, J_1=6.9 Hz, J_2=2.3 Hz, 2 H, aromatics), 4.95 (s, 1 H, NCHN), 3.73 (d, *J*= 12.8 Hz, 1 H, CH*H*Ar), 3.70 (s, 3 H, OCH_3), 3.48 (d, *J*=12.8 Hz, 1 H, CH*H*Ar), 3.22-3.14 (m, 2 H, CH_2N), 2.89-2.82 (m, 2 H, CH_2N). MS: *m/z*= 344 ($M^{+\cdot}$). Anal. Calcd for $C_{23}H_{24}N_2O$: C; 80.20, H; 7.02, N; 8.13. Found: C; 80.29, H; 7.04, N; 8.10.

Synthesis of 1*H*-4,5-Dihydroimidazolium Salts (1).

Reaction of Imidazolidines (2) with *N*-Bromosuccinimide, *N*-Bromoacetamide or 1,3-Dibromo-5,5-dimethylhydantoin. General Procedure.

To a stirred solution of compounds (**2**) (10 mmol) in THF (30 mL), the corresponding dehydrogenating agent (12 mmol) was added in portions while the reaction was monitoried by TLC. After complete disappearance of starting material, salts precipitate in variable times (Table 2); otherwise precipitation was induced by adding ethyl ether. The solid products were collected and recrystallized from anhydrous methanol and the oils were purified by chromatographyc method using chloroform-methanol (8:2) as the solvent.

Melting points and ^{1}H-NMR data are given in Table 3. Elemental analyses of the new compounds are as follows.

1,3-Dibenzyl-4,5-dihydro-1*H*-imidazolium bromide (1a)

Anal. Calcd for $C_{17}H_{19}N_2Br$: C; 61.64, H; 5.78, N; 8.40. Found: C; 61.73, H; 5.80, N; 8.38.

1,3-Di-(4-methoxybenzyl)-4,5-dihydro-1*H*-imidazolium bromide. (1b)

Anal. Calcd for $C_{19}H_{23}N_2O_2Br$: C; 58.32, H; 5.92, N; 7.16. Found: C; 58.42, H; 5.91, N; 7.18.

1,3-Di-(4-chlorobenzyl)-4,5-dihydro-1*H*-imidazolium bromide (1c)

Anal. Calcd for $C_{17}H_{17}N_2BrCl_2$: C; 51.03, H; 4.28, N; 7.00. Found: C; 51.10, H; 4.26, N; 7.02.

1,3-Di-(3,4-dichlorobenzyl)-4,5dihydro-1*H*-imidazolium bromide (1d)

Anal. Calcd for $C_{17}H_{15}N_2BrCl_4$: C; 43.53, H; 3.22, N; 5.97. Found: C; 43.48, H; 3.23, N; 5.99.

1,3-Di-(4-methoxybenzyl)-2-methyl-4,5-dihydro-1*H*-imidazolium bromide (1e)

Anal. Calcd for $C_{20}H_{25}N_2OBr_2$: C; 59.26, H; 6.22, N; 6.91. Found: C; 59.37, H; 6.21, N; 6.93.

1,3-Di-(4-methoxybenzyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide. (1g)

Anal. Calcd for $C_{25}H_{27}N_2O_2Br$: C; 64.24, H; 5.82, N; 5.99. Found: C; 64.15, H; 5.83, N; 6.01.

1,3-Di-(4-chlorobenzyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide (1h)

Anal. Calcd for $C_{23}H_{21}N_2BrCl_2$: C; 58.01, H; 4.44, N; 5.88. Found: C; 58.11, H; 4.45, N; 5.86.

1,3-Di-(3,4-dichlorobenzyl)-2-phenyl-4,5dihydro-1*H*-imidazolium bromide (1i)

Anal. Calcd for $C_{23}H_{19}N_2BrCl_4$: C; 50.68, H; 3.51, N; 5.14. Found: C; 50.59, H; 3.52, N; 5.15.

1,3-Di-(4-chlorobenzyl)-2-(4-chlorophenyl) -4,5-dihydro-1*H*-imidazolium bromide (1j)

Anal. Calcd for $C_{23}H_{20}N_2BrCl_3$: C; 54.09, H; 3.95, N; 5.49. Found: C; 54.20, H; 3.96, N; 5.47.

1,3-Di-(4-chlorobenzyl)-2-(4-methoxyphenyl)-4,5-dihydro-1*H*-imidazolium bromide (1k)

Anal. Calcd for $C_{24}H_{23}N_2OBrCl_2$: C; 56.94, H; 4.58, N; 5.53. Found: C; 57.03, H; 4.60, N; 5.51.

1,3-Di-(4-chlorobenzyl)-2-(3,4-dichlorophenyl)-4,5-dihydro-1*H*-imidazolium bromide (1l)

Anal. Calcd for $C_{23}H_{19}N_2BrCl_4$: C; 50.68, H; 3.51, N; 5.14. Found: C; 50.77, H; 3.49, N; 5.13.

1,3-Di-(4-chlorobenzyl)-2-(3-chlorophenyl)-4,5-dihydro-1*H*-imidazolium bromide (1m)

Anal. Calcd for $C_{23}H_{20}N_2BrCl_3$: C; 54.09, H; 3.95, N; 5.49. Found: C; 53.98, H; 3.97, N; 5.51.

1-Benzyl-3-(4-methylphenyl)-4,5-dihydro-1*H*-imidazolium bromide (1n)

Anal. Calcd for $C_{17}H_{19}N_2Br$: C; 61.64, H; 5.78, N; 8.46. Found: C; 61.71, H; 5.76, N; 8.45.

1-Benzyl-3-(4-chlorophenyl)-4,5-dihydro-1*H*-imidazolium bromide (1o)

Anal. Calcd for $C_{16}H_{16}N_2BrCl$: C, 54.65; H, 4.59; N, 7.97. Found: C; 54.72, H; 4.57, N; 7.96.

1-Benzyl-3-(4-nitrophenyl)-4,5-dihydro-1*H*-imidazolium bromide (1p)

Anal. Calcd for $C_{16}H_{16}N_3O_2Br$: C; 53.05, H; 4.45, N; 11.60. Found: C; 53.15, H; 4.44, N; 11.59.

1-Benzyl-3-(4-methoxyphenyl)-4,5-dihydro-1*H*-imidazolium bromide (1q)

Anal. Calcd for $C_{17}H_{19}N_2OBr$: C; 58.80, H; 5.51, N; 8.07. Found: C; 58.71, H; 5.53, N; 8.08.

1-Benzyl-3-(4-methylphenyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide (1r)

Anal. Calcd for $C_{23}H_{23}N_2Br$: C; 67.82, H; 5.69, N; 6.88. Found: C; 67.91, H; 5.67, N; 6.87.

1-Benzyl-3-(4-chlorophenyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide (1s)

Anal. Calcd for $C_{22}H_{20}N_2BrCl$: C; 61.77, H; 4.71, N; 6.55. Found: C; 61.83, H; 4.70, N; 6.54.

1-Benzyl-3-(4-nitrophenyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide (1t)

Anal. Calcd for $C_{22}H_{20}N_3O_2Br$: C; 60.28, H; 4.60, N; 9.59. Found: C; 60.38, H; 4.59, N; 9.57.

1-Benzyl-3-(4-methoxyphenyl)-2-phenyl-4,5-dihydro-1*H*-imidazolium bromide (1u)

Anal. Calcd for $C_{23}H_{23}N_2OBr$: C; 65.25, H; 5.48, N; 6.62. Found: C; 65.19, H; 5.50, N; 6.64.

Reaction of Imidazolidines (2) with Carbon Tetrachloride. General Procedure.

A solution of imidazolidine (0.5 mmol) in carbon tetrachloride (100 mL) was refluxed, and the reaction was monitored by TLC, until disappearance of the starting material (1-6 h). The resulting solids were filtered and recrystallized from methanol.

ACKNOWLEDGEMENTS

This work was financially supported by the University de Buenos Aires. The authors thank J. Duran and M. Agman for technical assistance.

REFERENCES

1. R. L. Blakey and S. J. Benkovic, ed. “Folates and Pteridines”, Vol **1**, Wiley, New York, 1984; Vol. **2** John Wiley, and Sons, New York, 1985.
2. H. C. S. Wood, “Comprehensive Organic Chemistry”, Vol 5, ed. by E. Haslam, Chapter 24.3, Pergamon, Oxford, 1979.
3. R. G. Matthews and J. T. Drummond, *Chem. Rev.,* 1990, **90**, 1275.
4. U. K. Pandit and H. Bieraugel, *J. Chem. Soc., Chem. Commun.,* 1979, 117; H. Bieraugel, R. Plemp, H. C. Hiemstra, and U. K. Pandit, *Tetrahedron,* 1983, **39**, 3971; M. W. Anderson, R. C. F. Jones, and J. Saunders, *J. Chem. Soc. Chem., Commun.,* 1982, 282; M. W. Anderson, R. C. F. Jones, and J. Saunders, *J. Chem. Soc., Perkin Trans. 1,* 1986, 1995; S. J. Benkovic, W. P. Bullard, and P. A. Benkovic, *J. Am. Chem. Soc.,* 1972, **94**, 7542; B. A. Burdick, P. A. Benkovic, and S. J. Benkovic, *J. Am. Chem. Soc.,* 1973, **99**, 5716.

5. A. Salerno, V. Ceriani, and I. A. Perillo, *J. Heterocycl. Chem.,* 1997, **34**, 709.
6. I. Perillo and S. Lamdan, *J. Chem. Soc., Perkin Trans. 1,* 1975, 894.
7. B. Fernández, I. Perillo, and S. Lamdan, *J. Chem. Soc., Perkin Trans. 2,* 1978, 545.
8. See for example: B. M. Fernández, A. M. Reverdito, G. A. Paolucci, and I. A. Perillo, *J. Heterocycl. Chem.,* 1987, **24**, 1717; A. Marxer, *J. Am. Chem. Soc.,* 1957, **79**, 467; B. C. Trivedi, A. J. Digioia, and P. J. Menardi, *J. Am. Oil Chem. Soc.,* 1981, **58**, 754; E. R. Shepards and H. A. Shonle, *J. Am. Chem. Soc.,* 1943, **69**, 2269.
9. J. Beger, C. Nestmann, R. Neumann, and R. Ruestig, *Tenside Deterg.,* 1980, **17**, 79.
10. W. A. Herrmann, *Angew. Chem., Int. Ed.,* 2002, **41**, 1290.
11. H. Y. Zhou, E. J. Campbell, and S. T. Nguyen, *Org. Lett.,* 2001, **3**, 2229.
12. J. Hocker and R. Merten, *Angew. Chem., Int. Ed. Engl.,* 1972, **11**, 964.
13. L. Jaenicke and E. Brode, *Liebigs Ann. Chem.,* 1959, **624**, 120.
14. J. D. Wilson, C. F. Hobbs, and H. Weingarten, *J. Org. Chem.,* 1970, **35**, 1542.
15. S. Saba, A. M. Brescia, and M. K. Kaloustian, *Tetrahedron Lett.,* 1991, **32**, 5031.
16. See for example: R. A. Donia, J. A. Shotton, L. O. Bentz, and G. E. P. Smith Jr., *J. Org. Chem.,* 1949, **14**, 952; J. H. Billman, J. Y. C. Ho, and L. R. Caswell, *J. Org. Chem.,* 1952, **17**, 1375; C. Chapuis, A. Gauvreau, A. Klaebe, A. Lattes, and J. J. Perie, *Bull. Soc. Chim. Fr.,* 1973, 977; J. B. Lambert, D. E. Museland, and G. Wang, *Synthesis,* 1986, 657.
17. A. Salerno, C. Caterina, and I. A. Perillo, *Synth. Commun.,* 2000, **30**, 3369, and references cited therein.
18. A. Salerno, M. A. Figueroa, and I. A. Perillo, *Synth. Commun.,* 2003, **33**, 3193.
19. N. Jain, A. Kumar, S. Chauhan, and S. M. S. Chauhan, *Tetrahedron,* 2005, **61**, 1015, and references cited therein.
20. V. Juřčik and R. Wilhelm, *Org. Biomol. Chem.,* 2005, **3**, 239.
21. N. Kalyanam, P. C. Parthasarathy, L. Ananthan, S. G. Manjunatha, and M. A. Likhate, *Indian J. Chem. Sent. B,* 1992, **31B**, 243.
22. E. D. Bergmann, E. Zimkin, and S. Pinchas, *Rec. Trav. Chim*., 1952, **71**, 168.
23. W. L. Wilson and M. J. LeBelle, *J. Pharm. Sci.,* 1979, **68**, 1322.
24. J. H. Billman, J.-Y. C. Ho, and L. R. Caswell, *J. Org. Chem.*, 1957, **22**, 538.
25. A. Salerno, M. E. Hedrera, N. B. D´Accorso, M. Martins Alho, and I. A. Perillo, *J. Heterocycl. Chem.,* 2000, **37**, 57.
26. A. Salerno, I. A. Perillo, and G. Buldain, *Rev. Farm.,* 2000, **141**, 7.