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Synthesis, Fragmentations and Rearrangements of 3-(1-Haloalkyl)oxaziridines

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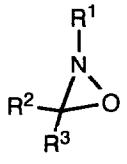
Abstract

A variety of new 3-(1-haloalkyl)oxaziridines was synthesized by oxidation of α-chloro-, α-bromo-, α,α-dichloro-, α,α-dibromo- and α,α,α-trichloroaldimines with meta-chloroperbenzoic acid. Attempts to induce dehydrohalogenation into the elusive methyleneoxaziridines were unsuccessful. However, presumptive evidence is presented that 2-t-butyl-3-(trichloromethyl)oxaziridine is dehydrochlorinated into a transient methyleneoxaziridine, which underwent valence isomerization into an intermediate iminooxirane, the latter being fragmented into t-butyl isocyanide. Various types of reactions of the title compounds are reported. Among others, 2-alkyl-3-(1-chloro-1-methyl)ethyloxaziridines rearranged with methyllithium into 2-(N-alkyl)aminoisobutyraldehydes.

Introduction

Oxaziridines 1 represent a class of reactive three-membered heterocycles which, since their discovery by Emmons[3], remains the object of considerable study in view of their practical and theoretical interest.[4-7] Salient features of the chemistry of oxaziridines are, among others, the isomerization into amides[4,8] or nitrones,[4] the fragmentation with lithium amides (electron transfer reaction),[9] the nucleophile-induced deoxygenation[9,10] and the base-induced fragmentation into N-unsubstituted imines.[11-14]



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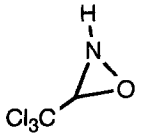
Oxaziridines show a remarkable configurational stability about nitrogen and there are many examples of pairs of isomers which are separable.[15] Oxaziridines are usually prepared by the oxidation of imines with peracids. Contrary to the epoxidation of alkenes, the conversion of imines into oxaziridines is presumably a stepwise reaction involving protonation of the imine.[16,17]

The knowledge on the reactions of oxaziridines has increased in the last decade but remained within the scope of the early investigations. Few functionalized oxaziridines have been studied hitherto.[18] N-Functionalized oxaziridines, e.g. 2-arenesulfonyloxaziridines[19,20] and 2-phosphinoyloxaziridines,[21] have proven their synthetic utility already, while some C-functionalized oxaziridines have been used in intramolecular dipolar cycloadditions derived from the interaction of transient nitrone intermediates with olefinic groups.[22] Apart from

some fluorinated oxaziridines,[23] reports of halogenated oxaziridines are extremely rare. One example concerns the condensation of chloral with hydroxylamine-O-sulphonic acid in the presence of primary amines which leads to 3-(trichloromethyl)oxaziridine 2 as an intermediate, the latter transferring its nitrogen atom to the primary amine to give N-alkylhydrazines.[24] Other examples include the description of the unstable functionalized bicyclic oxaziridine 3, which was only isolated in 3% yield,[25a] and the recent use of the so-called (-)-α,α-dichlorocamphorsulfonyloxaziridine 4 as a superior reagent for the asymmetric oxidation of sulfides to sulfoxides.[25b] Similar N-sulfonyloxaziridines have been utilized for the synthesis of chiral α-hydroxycarbonyl compounds.[25c-25d]



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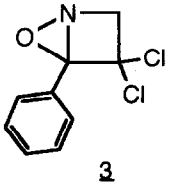

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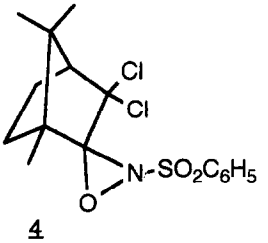

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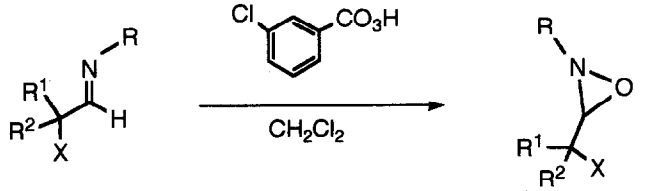
We here report on the synthesis of novel oxaziridines bearing halogens at the 1-position of the 3-alkyl substituent. Some of the reactions of these halogenated oxaziridines will be discussed. The purpose was to combine the chemical properties of the oxaziridine ring with the leaving group character of the halogens in order to find useful synthetic reactions. The potential of these halogenated oxaziridines to function as precursors for methyleneoxaziridines was investigated.

Results and Discussion

Reaction of α-halogenated aldimines 4 with metachloroperbenzoic acid in dichloromethane at room temperature produced oxaziridines 6, substituted with halogens at the 1-position of the 3-alkyl substituent.



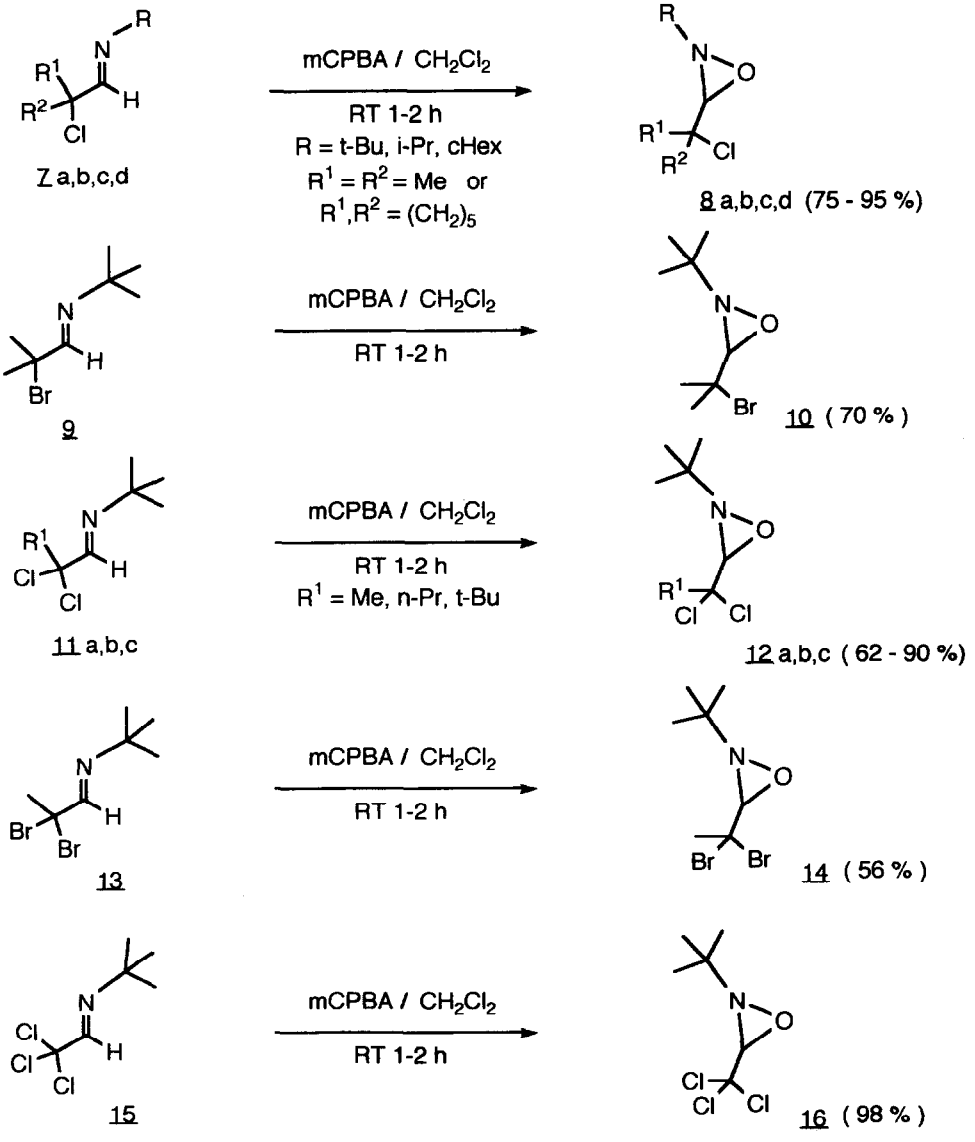
5 R = alkyl
R¹, R², X = Cl, Br, alkyl

6

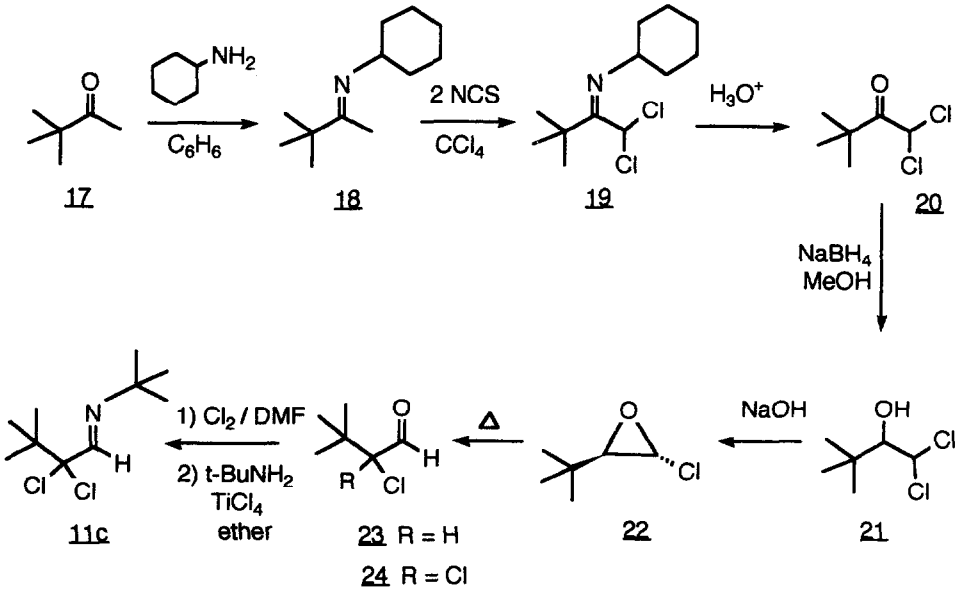
Accordingly, α-chloroaldimines 7, α-bromoaldimine 9, α,α-dichloroaldimines 11, α,α-dibromoaldimine 13 and α,α,α-trichloroaldimine 15 were converted into the corresponding oxaziridines 8, 10, 12, 14 and 16 in good

to excellent yields. The yields and spectrometric properties (^{1}H, MS) of the new halogenated oxaziridines are compiled in Table I. Table II describes the ^{13}C NMR data of these halogenated oxaziridines.

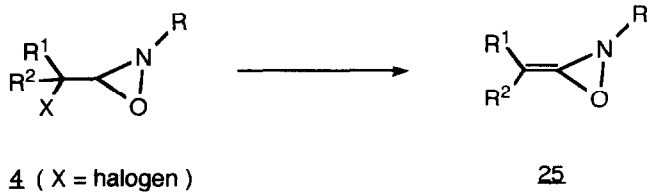
As evidenced from the spectral data (NMR), the halogenated oxaziridines occur as one geometrical isomer, i.e. most probably the trans disposition of the N-substituent and the haloalkyl substituent at the 3-position. It is indeed expected that the inversion at nitrogen is slow. As exemplified for 2-t-butyl-3-(1-chloro-1-methyl)-ethyloxaziridine 8a, the two methyls of the haloalkyl substituent at the 3-position resonate as singlets at 1.41 and 1.50 ppm in the ^{1}H NMR spectrum (CCl_4), while they exhibit two signals (quadruplet each) at 26.13 and 27.00 ppm in the ^{13}C NMR spectrum ($CDCl_3$).



The requisite α-haloaldimines were either prepared by halogenation of the corresponding aldimines with N-halosuccinimides[26-28] or by condensation of α-haloaldehydes with primary amines in the presence of stoichiometric amounts of titanium(IV) chloride[29] (see experimental section). 2,2-Dichloro-3,3-dimethylbutanal 24 was prepared by dichlorination of pinacolone 17 (SO_2Cl_2/CH_2Cl_2 or Cl_2/DMF, or imination with cyclohexylamine, dichlorination with NCS,[30,31] and hydrolysis[31]) followed by reduction of the carbonyl group by sodium borohydride and base-induced ring closure into α-chlorooxirane 22.[32] Thermal rearrangement of oxirane 22 gave α-chloroaldehyde 23,[32] which was further α-chlorinated with chlorine in DMF[33], the resulting 2,2-dichloro-3,3-dimethylbutanal 24 being converted into α,α-dichloroaldimine 11c as described previously.[29]



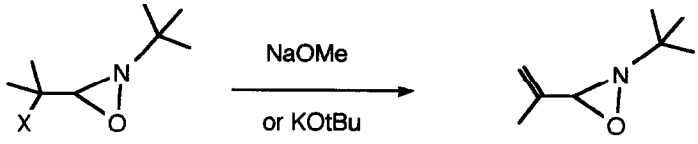
Halogenated oxaziridines 4 have the potential to act as suitable starting materials for the synthesis of the elusive methyleneoxaziridines 25. Up to now, attempts to generate this class of heteromethylenecyclopropanes



have been unsuccessful.[33,34] In order to test the possibility of synthesizing methyleneoxaziridines 17, halogenated oxaziridines 4 were treated with bases with the hope of getting 1,2-dehydrohalogenation.

The reaction of 2-t-butyl-3-(1-chloro-1-methyl)ethyloxaziridine 8a with potassium t-butoxide in ether did not lead to consumption of starting material at room temperature. After three hours of reflux and an overnight period at room temperature, only 20% conversion into 2-t-butyl-3-isopropenyloxaziridine 26 had taken place. The reaction with sodium methoxide in methanol (3 molar equivalents 2N) under reflux for 28 h afforded about 50% of the dehydrochlorinated oxaziridine 26, the remainder being starting material. The brominated analogue 10 reacted with sodium methoxide in methanol (4 equiv. 2N) under reflux for 6 hours to afford 90% of the 2-t-butyl-3-isopropenyloxaziridine 26.

Equimolar amounts of lithium diisopropylamide or lithium tetramethylpiperidide in ether at room temperature did not lead to dehydrochlorination of oxaziridine 8a, although some starting material was transformed into the corresponding α-chloroaldimine 7a (R = t-Bu; $R^1=R^2=Me$).



8a X = Cl
10 X = Br

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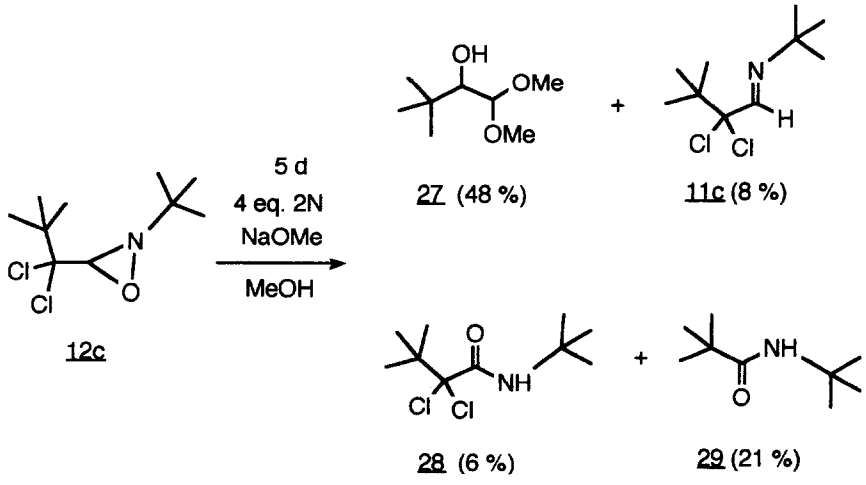
It is clear that the base-induced dehydrochlorination of oxaziridine 8a into the corresponding methyleneoxaziridine is not a favored process because of the tendency for dehydrochlorination towards 3-(1-al-



12c

27 (48 %)

11c (8 %)

28 (6 %)

29 (21 %)

kenyl)oxaziridines.[35] However, these 3-(1-alkenyl)oxaziridines are interesting new compounds, which came only very recently available by oxidation of α,ß-unsaturated aldimines.[36] This novel class of compounds was

Table I : Synthesis and Spectrometric Data of Halogenated Oxaziridines 8, 10, 12, 14, 16

Compound[a]	R	R^1	R^2	Yield	Bp. or mp.	^{1}H NMR	Mass spectrum (70 eV) m/z (%)
8a	t-Bu	Me	Me	87%[b]	72-80°C (14mmHg)	δ (CCl_4) : 1.06 (9H,s,t-Bu); 1.41 (3H,s, Me); 1.50 (3H,s,Me); 4.00 (1H,s, O-CH-N)	177/9 (M^+; 0.04); 161/3(0.1); 145/7(0.2); 141 (0.5); 124(0.4); 120/2(0.2); 110(0.6); 101(0.4); 98(0.3); 86(6); 85(2); 84(2); 77/9(3); 72(7); 57 (100); 56(14).
8b	i-Pr	Me	Me	75%[b]	55-59°C (18mmHg)	δ ($CDCl_3$) : 1.12 and 1.22 (each 3H, 6.5Hz, Me_2C-N); 1.47 (3H,s,Me); 1.50 (3H,s,Me); 2.25 (1H,septet, J=6.5Hz); 3.92 (1H,N-CH-O)	no M^+ : 148/50(0.2); 128(14); 86(21); 77(18); 72 (10); 58(24); 56(10); 55(18); 44(22); 43(100); 42 (57); 41(99); 39(66).
8c	cHex	Me	Me	93%	-[c,e]	δ (CCl_4) : 1-2.2 (11H,m,C_6H_{11}); 1.43 (3H,s, Me); 1.51 (3H,s,Me); 3.85 (1H, s,N-CH-O)	203/5 (M^+; 0.1); 188(4); 126(6); 98(3); 86(13); 83(33); 82(6); 67(13); 55(100); 54(9); 46(6); 44 (6); 43(13); 42(18); 41(86); 39(26).
8d	t-Bu	$(CH_2)_5$		95%	-[d]	δ (CCl_4) : 1.09 (9H,s,t-Bu); 1.4-2 (10H,m, $(CH_2)_5$); 4.02 (1H,s,N-CH-O)	217/9 (M^+; 0.5); 202/4(0.5); 182(4); 126(14); 81 (13); 57(100).
10	-	-	-	70%	78-80°C[e] (15mmHg)	δ (CCl_4) : 1.10 (9H,s,t-Bu); 1.60 (3H,s, Me); 1.70 (3H,s,Me); 4.13 (1H, s,N-CH-O)	no M^+; 142(3); 121/3(1); 120/2(2); 101(2); 98 (2); 86(42); 84(10); 72(14); 57(100); 56(22); 46 (6); 43(8); 42(14); 41(60); 39(14).
12a	-	Me	-	62%	78-80°C (21mmHg)	δ (CCl_4) : 1.13 (9H,s,t-Bu); 1.89 (3H,s, Me); 4.37 (s,N-CH-O)	197/99/201 (M^+; 0.05); 182/4/6(0.3); 166/68/70 (0.5); 97/99/101(3); 86(3); 84(3); 72(5); 57 (100); 56(9); 42(6); 41(20); 40(4); 39(3).
12b	-	n-Pr	-	90%	100-103°C (13mmHg)	δ (CCl_4) : 0.97 (3H,t,Me); 1.6 (2H,m, CH_2Me); 1.8 (2H,m,CH_2CCl_2); 1.10 (9H,s, t-Bu); 4.43 (1H,s,N-CH-O)	225/7/9 (M^+; 0.01); 210/2/4(0.1); 194/6/8(0.06); 134(0.3); 125/7/9(0.3); 94(0.4); 89(1.5); 86(3); 84(1); 72(5); 63(1.5); 57(100); 56(8); 55(2).
12c	-	t-Bu	-	85%	115-122°C (12mmHg)	δ (CCl_4) : 1.14 (9H,s,N-t-Bu); 1.23 (9H,s,t-BuCCl_2); 4.26 (1H,s,N-CH-O)	no M^+; 89(3); 86(3); 72(5); 57(100); 41(31).
14	-	-	-	56%	50-56°C (0.02mmHg)	δ ($CDCl_3$) : 1.13 (9H,s,t-Bu); 2.25 (3H,s,Me); 4.62 (1H,s,N-CH-O)	no M^+; 270/2/4(0.05); 112(7); 109(7); 84(6); 72 (3); 57(100); 56(10); 42(6); 41(22); 40(6); 39 (6).
16	-	-	-	98%	37°C	δ (CCl_4) : 1.19 (9H,s,t-Bu); 4.46 (1H,s, N-CH-O)	no M^+; 117/19/21/23(3); 83(7); 72(4); 57(100); 56(14); 55(10); 42(12); 41(32); 40(14).

a) All halogenated oxaziridines gave IR spectral data in accordance with the structure. These data are not tabulated. As an example, the IR data of strong absorptions in the fingerprint region of 2-t-butyl-3-(trichloromethyl)oxaziridine 16 are given here : 1362 - 873 - 823 - 798 - 739 cm^{-1} (KBr).

b) Yields of crude but pure oxaziridines are usually 90% at minimum. The reported yields are those after distillation.

c) Compound 8c decomposed violently upon attempted vacuum distillation.

d) Purity > 97% as evidenced by ^{1}H NMR.

e) Solidified in the freezer (-20°C).

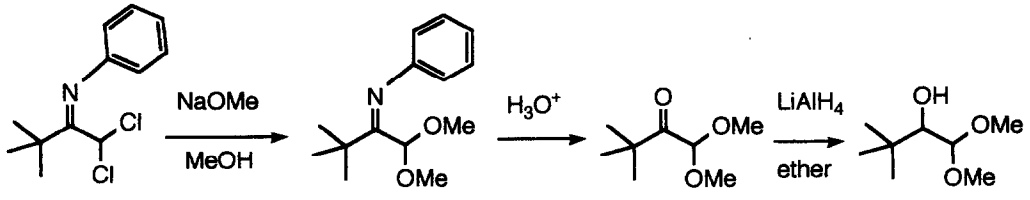
Table II : ^{13}C NMR Data of Halogenated Oxaziridines 8, 10, 12, 14 and 16 (δ, $CDCl_3$)

Compound	N-CH-O (d)	N-Substituent			3-Substituent		
		N-C	N-C-C	other	C-1(s)	C-2	C-3
8a	79.25	57.90(s)	25.23(q)	-	66.66	26.13(q)	-
						27.00(q)	
8b	85.41	61.79(d)	21.18(q)	-	66.30	26.06(q)	-
			18.74(q)			27.04(q)	
8c	85.28	69.08(d)	31.46(t)	23.88(t)	66.42	26.14(q)	-
			29.14(t)	24.37(t)		27.06(q)	
				25.80(t)			
10	79.63	57.89(s)	25.16(q)	-	61.59	27.08(q)	-
						28.53(q)	
12a	79.10	58.51(s)	25.16(q)	-	85.97	28.98(q)	-
12c	75.74	58.63(s)	25.47(q)	-	-[a]	43.50(s)	26.41(q)
14	80.03	58.46(s)	25.20(q)	-	62.68	31.62(q)	
16	80.23	50.29(s)	25.36(q)	-	96.33	-	-

a) The CCl_2 signal was not visible.

shown to exert some antitumor activity.[36]

In order to avoid this undesired reaction, the 2-position of the 3-(1-haloalkyl) substituent was blocked. To this end 2-t-butyl-3-(1,1-dichloro-2,2-dimethyl)propyloxaziridine 12c was prepared and reacted with lithium diisopropylamide in ether. No trace of reaction occurred after a prolonged period at room temperature or even after 22 h of reflux. Also, under more stringent conditions, this sterically hindered oxaziridine 12c could not be dehydrochlorinated, as exemplified by the total recovery after a reflux of five days with potassium t-butoxide (1.5 equiv.) in tetrahydrofuran. Only the reaction of oxaziridine 12c with sodium methoxide in methanol under reflux for five days led to consumption of starting material, resulting in a complex reaction mixture. The various compounds were separated by preparative gas chromatography, which revealed the product distribution as follows : 48% 1,1-dimethoxy-3,3-dimethyl-2-butanol 27, 21% N-t-butyl 2,2-dimethylpropanamide 29, 8% N-(2,2-dichloro-3,3-dimethyl-1-butylidene)t-butylamine 11c and 6% N-t-butyl 2,2-dichloro-3,3-dimethylbutanamide 28. This extremely slow reaction of oxaziridine 12c (only about 5% conversion of starting material after 21 h of reflux) resulted in 8% deoxygenation (11c) and 6% rearrangement into the isomeric amide 28. The major compound was identified as α-hydroxyacetal 27 by spectroscopic methods and by comparison with an authentic sample prepared from nucleophilic substitution of dichloromethylketimine 30 by sodium methoxide,[37] subsequent hydrolysis[37] and reduction with lithium aluminium hydride. Its formation might result via deoxygenation of 12c into 11c, followed by hydrolysis into the corresponding α,α-dichloroaldehyde, subsequent rearrangement into 1,1-dimethoxy-3,3-dimethyl-2-butanone and, finally, reduction of the carbonyl in the latter compound by methoxide (cf. very long reaction time; no complete protection against moisture). It is indeed known that methoxide under severe conditions can act as a hydride donor, resulting in reduction of carbonyl groups.[38]



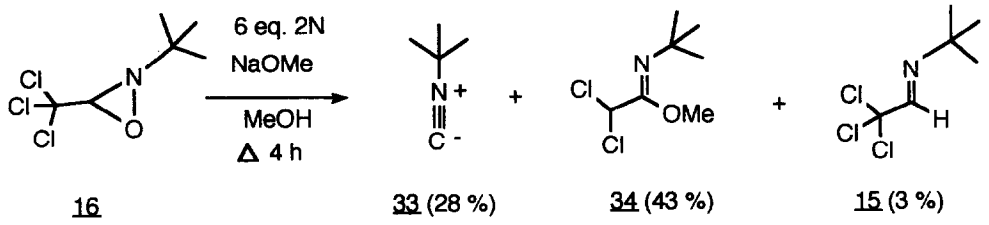
30 31 32 27

The isomerization of oxaziridine 12c into amide 28 can be explained by consecutive deprotonation and ring opening of the oxaziridine to give the anion of 28.[9]

The presence of the pivalic amide 29 is less clear, although various reaction pathways, including hydrolysis by adventitious water, can be devised.

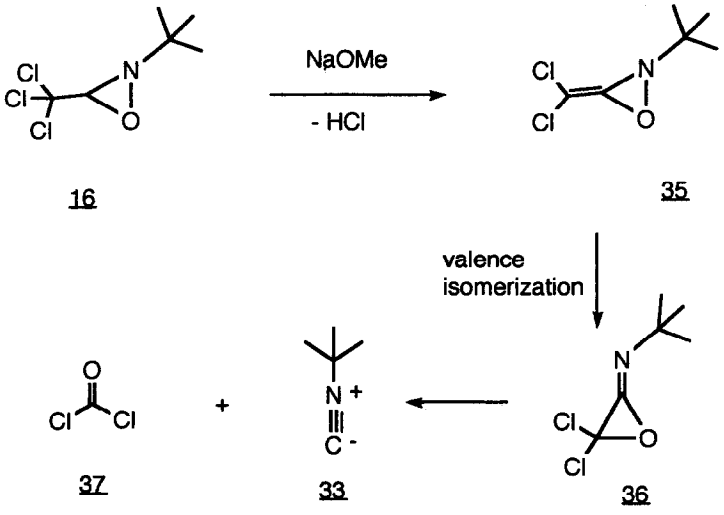
The failure of oxaziridine 12c to afford dehydrochlorination into methyleneoxaziridines led us to try the same type of transformation with 2-t-butyl-3-(trichloromethyl)oxaziridine 16. The reaction of oxaziridine 16 with sodium methoxide in methanol (6 molar equiv. 2N) under reflux occurred much faster than the reaction with oxaziridine 12c. After 4 h of reflux, oxaziridine 16 was transformed into 28% t-butyl isocyanide 33, 43% methyl N-t-butyl dichloroacetimidate 34 and 3% N-(2,2,2-trichloroethylidene)t-butylamine 15 (^{1}H NMR; GLC). The presence of α,α,α-trichloroaldimine 15 again points to deoxygenation of oxaziridine 16, but most of the α,α,α-trichloroaldimine 15, as expected, had reacted with methoxide by an addition-elimination mechanism into

imidate 34.[39,40] The identification of t-butyl isocyanide, easily established spectroscopically by the characteristic triplet (lines of equal intensity) of the t-butyl signal (^{1}H NMR) due to the resolvable long-range ^{14}N-^{1}N coupling,[41] leaves some space for speculation on its formation. It is clear that a molecular rearrangement leading to a transient species, which can eliminate t-butyl isocyanide, is a good candidate. Such a process might be the desired 1,2-dehydrochlorination of oxaziridine 16 into the methyleneoxaziridine 35. Valence iso-



16 33 (28 %) 34 (43 %) 15 (3 %)

merization of this transient compound 35 into the iminooxirane 36 could produce a suitable species for elimination of t-butyl isocyanide 33.[43] Phosgene 37 would certainly react with methanol to produce dimethyl carbonate (no attempts were made to identify the latter).

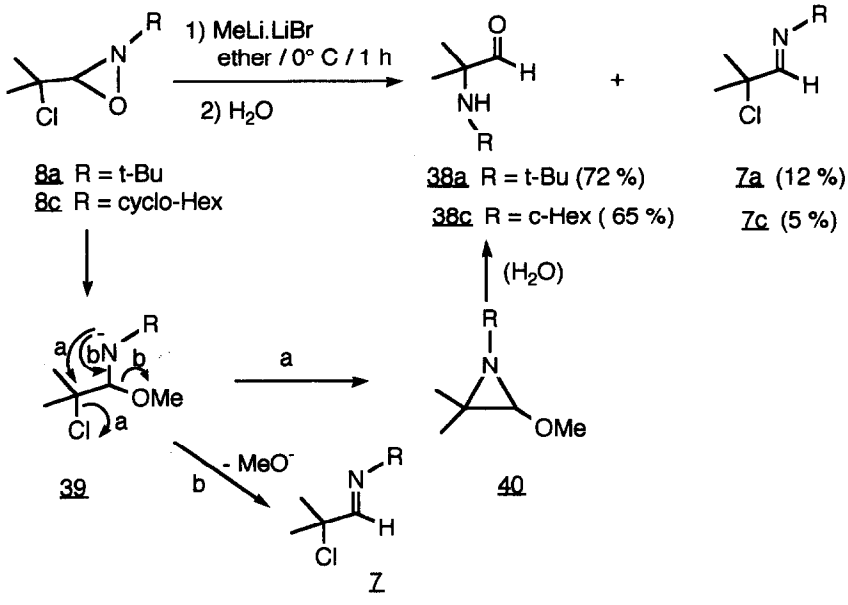


16 35 37 33 36

Valence isomerization of hetero(methylenecyclopropanes) is a well-studied area and many examples exist in which three-membered rings, bearing an exocyclic double bond, undergo this transformation, sometimes accompanied by the elimination of carbenoid species such as isocyanides.[44-47] Therefore, the identification of t-butyl isocyanide from the base-induced reaction of oxaziridine 16 might be an indication of the generation of a transient methyleneoxaziridine 35 and its valence isomerization into iminooxirane 36.[43] The corresponding N-phenyl derivative, i.e. 2,2-dichloro-3-(phenylimino)oxirane, was already postulated as an intermediate in the

pyrolytic decomposition (530°C) of N-phenyl trichloroacetamide, which produced phenyl isocyanide and phosgene.[42]

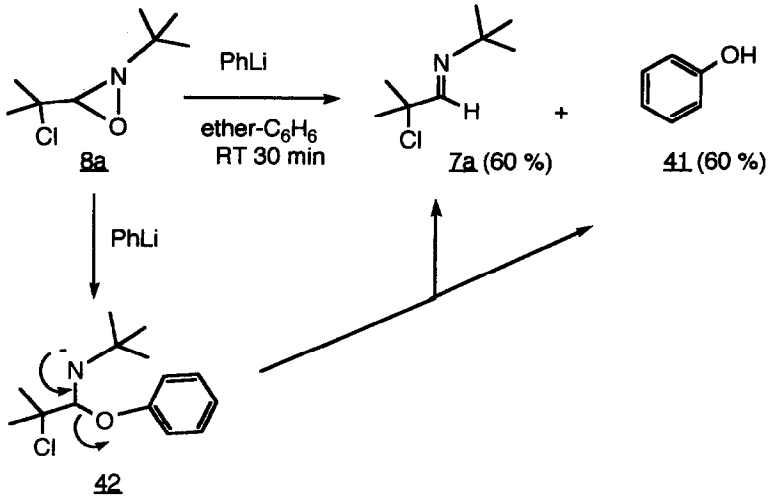
Organometallic reagents, e.g. alkyllithiums, Grignard reagents and phenyllithium are known to react with oxaziridines to give coupling and/or hydroxylation of the organometallic species.[48] It was challenging to investigate the role of the halogen in halogenated oxaziridines, when they are treated with organometallic reagents and to verify whether or not 1,2-dehydrohalogenations could take place into methyleneoxaziridines. To this end, N-t-butyl and N-cyclohexyl oxaziridines 8a and 8c were reacted with methyllithium (1.1-1.5 equiv.) in ether at 0°C. After the vigorous reaction, aqueous workup afforded a reaction mixture in which the rearranged α-(N-alkyl)aminoaldehyde 38 was the main product (65-72%), accompanied by α-chloroaldimines 7 (5-12%).



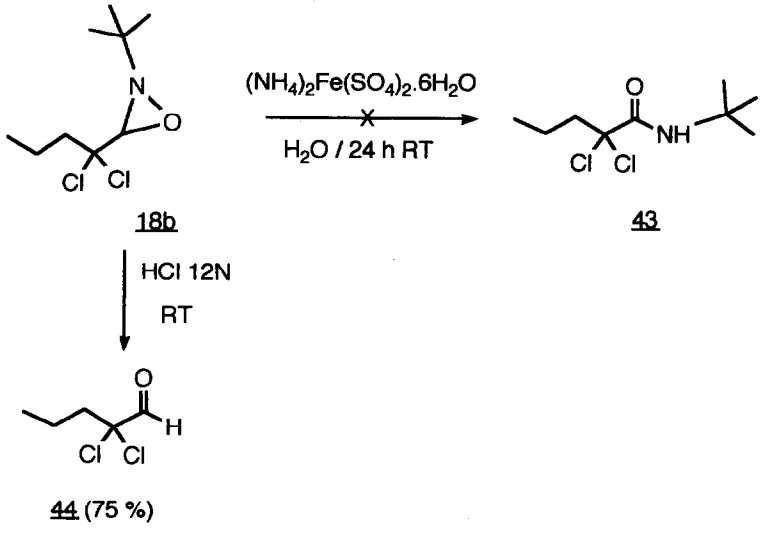
The results are interpreted as attack of the oxaziridine oxygen by methyllithium giving rise to the adduct 39. The latter can expel methoxide to afford α-chloroaldimine 7 but can also give rise to an intramolecular nucleophilic substitution which yields an intermediate reactive 2-methoxyaziridine 40. Aqueous workup finally hydrolizes this transient aziridine 40 into the corresponding α-(N-alkyl)aminoaldehyde 38. This reaction shows the potential of an adjacent functional group in directing the reaction from the known behavior towards a novel reaction pattern.

The transfer of the oxaziridine oxygen of halogenated oxaziridines to organic substrates was also accomplished with phenyllithium. The reaction of 2-t-butyl-3-(1-chloro-1-methyl)ethyloxaziridine 8a with one equivalent of phenyllithium in ether at room temperature afforded 60% N-(2-chloro-2-methyl-1-propylidene)t-butylamine 7a and 60% phenol 41. The formation of phenol can be explained by attack of the oxaziridine oxygen by phenyllithium,[48] after which phenol is expelled to afford α-chloroaldimine 7a. It has been reported

previously that organolithium and organomagnesium compounds are hydroxylated by 2-t-butyl-3-phenyloxaziridine or 2-benzenesulfonyl-3-phenyloxaziridine.[48]



Ferrous ammonium sulfate is known to convert oxaziridines into the corresponding amides.[4] However, employing the reaction conditions of Emmons,[4] i.e. reaction with one molar equivalent of aqueous Mohr's salt, 2-t-butyl-3-(1,1-dichlorobutyl)oxaziridine 12b was completely recovered after 24 h.



Deoxygenation of oxaziridine 12b did not occur with excess of 2N aqueous hydrogen chloride at room temperature, but was conveniently performed with excess of 12N aqueous hydrogen chloride. However, the resulting α,α-dichloroaldimine could not be isolated under the hydrolytic conditions and led to 75% of 2,2-dichloropentanal 44. During this reaction chloride ion was oxidized to chlorine, which could be easily detected by its smell.

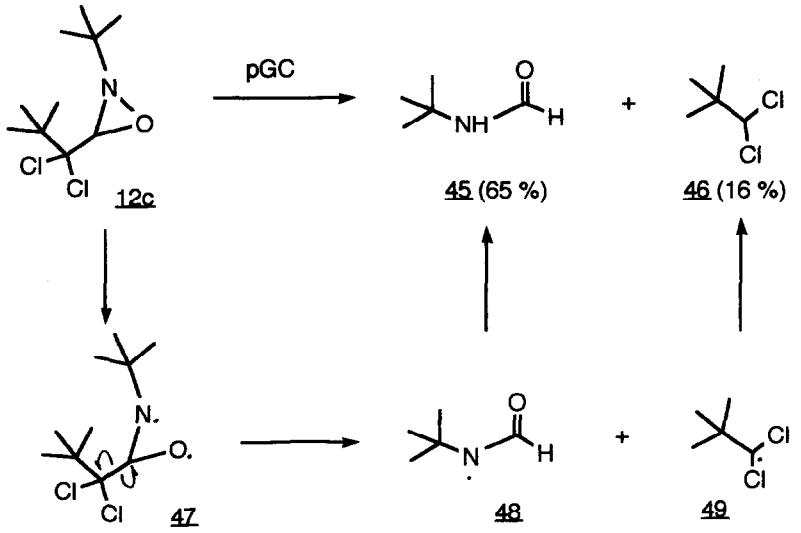
The thermal fragmentation of halogenated oxaziridines is a remarkable process. Although most of the new oxaziridines described in this paper can be distilled under vacuum without decomposition, they suffer from thermal fragmentation during gas chromatography (stainless steel column; 3 m; 5% SE 30 or polyphenylether; chromosorb W; injector temperature 285°C).

2-t-Butyl-3-(1-chloro-1-methyl)ethyloxaziridine 8a mostly survived the preparative gas chromatography but the collected sample always contained some rearranged amide, i.e. N-t-butyl 2-chloro-2-methylpropanamide.

Preparative gas chromatographic analysis of neat 2-t-butyl-3-(1,1-dichloro-2,2-dimethyl)propyloxaziridine 12c gave 65% N-t-butyl formamide 45 and 16% 1,1-dichloro-2,2-dimethylpropane 46, in addition to about 15% of an unidentified compound.

The fragmentation of oxaziridine 12c into 45 and 46 might be explained by N-O bond fission followed by carbon-carbon bond breaking to give radicals 48 and 49, which capture a hydrogen to afford the fragmentation products.

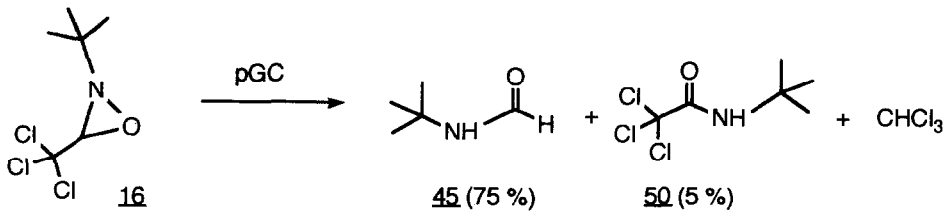
In similar way, 2-t-butyl-3-(trichloromethyl)oxaziridine 16 upon preparative gas chromatographic analysis (column temperature 135°C; injector temperature 225°) was converted into 78% N-t-butyl formamide 45, 5% of N-t-butyl trichloroacetamide 50 and small amounts of chloroform. It should be mentioned here that the solid



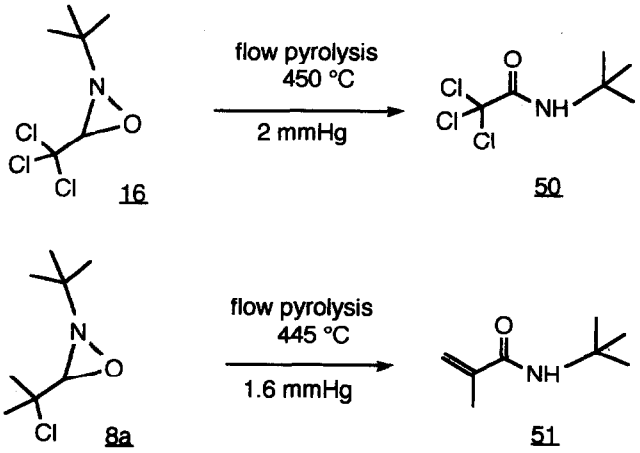
trichloromethyloxaziridine 16 was injected as a concentrated solution in ether. A more dilute solution of oxaziridine 16 was investigated by GC-MS coupling, revealing the same fragmentation, although the proportion of the amide 50 increased substantially.

Attempts to pyrolyze halogenated oxaziridines on a larger scale (1 mmol) in a flow pyrolysis apparatus met with little success.[49] The isolated products were sufficiently pure (> 90%) but were isolated in low yields. Pyrolysis of 2-t-butyl-3-(1-chloro-1-methyl)ethyloxaziridine 8a at 275°C (2.4 mmHg) gave only recovered starting material but pyrolysis at 445°C (1.6 and 2.2 mmHg) afforded 36-50% N-t-butyl 2-methylpropenamide 51 (rearrangement and dehydrochlorination). On the other hand, 2-t-butyl-3-trichloromethyloxaziridine 16 was pyrolyzed at 450°C (2 mmHg) to N-t-butyl trichloroacetamide 50 in 22% yield. The purpose of this study was

to discover whether or not it would be possible to dehydrochlorinate oxaziridines 8a and 16 into the corresponding methyleneoxaziridines in a thermal reaction. The preliminary results indicate that the hetero-



cyclic ring is too labile under the conditions of the pyrolysis experiments.



Also the dehydrohalogenation of various halogenated oxaziridines using the VGSR-technique[50] (Vacuum Gas Solid Reactions, i.e. vacuum evaporation of the substrates over a solid base such as potassium t-butoxide) did not give rise to the desired methyleneoxaziridines. The reactions at 60°C, 100°C or 120°C gave recovered starting material while the reactions at 195°C over potassium t-butoxide, deposited on silica gel, afforded an intractable and complex mixture of products which was not further investigated.[51]

Experimental Part

Infrared spectra were recorded with a Perkin Elmer model 1310 spectrophotometer. ^{1}H NMR spectra were measured with a Varian T-60 NMR spectrometer while ^{13}C NMR spectra were recorded with a Varian FT-80 NMR spectrometer (20 MHz). Mass spectra were obtained with a Varian MAT 112 mass spectrometer (70 eV) using a direct inlet system or by using a GC-MS coupling (capillary column).

α-Halogenated aldimines were synthesized as previously reported : 7a,[26] 7b,[26] 7c,[26] 7d,[26] 9,[27] 11a,[28] 15.[29] Compound 13 is a new compound and was prepared according to our previously reported method.[27] N-(2,2-Dibromo-1-propylidene)t-butylamine 13 : Bp. 70-80°C/32 mmHg (decomposition during distillation). ^{1}H NMR

(CCl_4) δ 1.20 (9H,s,t-Bu); 2.60 (3H,s,Me); 7.83 (1H,s,CH=N). IR (NaCl) : 1653 cm^{-1} ($\nu_{C=N}$). ^{13}C NMR ($CDCl_3$) : 29.09 (q,Me_3); 35.09 (q,Me); 56.07 (C=N-C); 62.08 (s,CBr_2); 156.03 (s,C=N). Mass spectrum m/z (%) : no M^+; 254/6/8(0.1); 175/7(2); 160/2(1); 134/6(3); 96(2); 84(40); 57(100); 56(6); 55(2); 54(2); 42(5); 41(17); 40(4); 39(8).

α,α-Dichloroaldimine 11c (R^1=t-Bu) was prepared by condensation of 2,2-dichloro-3,3-dimethylbutanal 24 with t-butylamine in the presence of titanium(IV) chloride.[29] The starting α,α-dichloroaldehyde 24 (R=Cl) was prepared from pinacolone in a reaction sequence as described in the text (vide supra).

Synthesis of Oxaziridines 8, 10, 12, 14 and 16 from α-Halogenated Aldimines

A stirred solution of an appropriate α-halogenated aldimine (7, 9, 11, 13, 15) (0.03 mol) in dry dichloromethane (10% w/v solution) was treated portionwise over 10 minutes with metachloroperbenzoic acid (0.033 mol). The reaction mixture was further stirred during 1-2 hours at room temperature, after which it was filtered if a precipitate were present. The precipitate was washed with little ether. The combined filtrates were then washed successively with aqueous sodium bisulfite, 0.5 N sodium hydroxide or potassium carbonate and brine. The organic phase was dried ($MgSO_4$) and the solvent was evaporated in vacuo. The remaining oils were very pure halogenated oxaziridines 8, 10, 12, 14 and 16, almost free from any side product (purity > 90%) (Table I). Vacuum distillation afforded all compounds as colorless liquids, except 8c which decomposed upon distillation. 2-t-Butyl-3-(trichloromethyl)oxaziridine 16 was obtained as a white crystalline compound, which was recrystallized from ether, mp. 37°C.

Elemental analysis :

Compound 8a : 7.77% N found, 7.88% N calcd.; 19.71% Cl found, 19.95% Cl calcd. Compound 8b : 8.46% N found, 8.56% N calcd.; 21.86% Cl found, 21.66% Cl calcd. Compound 8d : 6.49% N found, 6.43% N calcd., 16.39% Cl found, 16.28% Cl calcd. Compound 10 : 6.20% N found, 6.31% N calcd. Compound 12a : 7.20% N found, 7.07% N calcd.; 35.86% Cl found, 35.79% Cl calcd. Compound 12b : 6.03% N found, 6.19% N calcd.; 31.49% Cl found, 31.35% Cl calcd. Compound 12c : 5.98% N found, 5.83% N calcd.; 29.70% Cl found, 29.52% Cl calcd. Compound 14 : 5.01% N found, 4.88% N calcd. Compound 16 : 7.73% N found, 7.65% N calcd.; 38.61% Cl found, 38.73% Cl calcd.

Reaction of Halogenated Oxaziridines with Bases

The appropriate oxaziridine (0.01 mol) was reacted with various bases, including sodium methoxide, potassium t-butoxide, lithium diisopropylamide or lithium 2,2,6,6-tetramethylpiperidide, in the solvents described in the text. After stirring at the given temperature (see text) and for the time indicated in the text, workup was performed by trituration with water and extraction (three times) with dichloromethane or ether. After drying ($MgSO_4$ or K_2CO_3), the solvent was removed by distillation over a 5 cm Vigreux column at atmospheric pressure in order to avoid loss of volatile reaction products from fragmentation processes. The reaction mixtures were analyzed by ^1H NMR spectroscopy and preparative gas chromatography (Varian 1700 and Varian 920 gas chromatographs, equipped with stainless steel columns, 3 m, 5% SE 30 or polyphenylether, Chromosorb W). Volatile compounds were collected in U-shaped tubes, the bottom part being immersed in ice water or liquid air.

Synthesis of 1,1-dimethoxy-3,3-dimethyl-2-butanol (27)

1,1-Dimethoxy-3,3-dimethyl-2-butanone (32) was prepared from pinacolone via the corresponding N-phenylketimine, N-phenyl α,α-dichloroketimine and N-phenyl α,α-dimethoxyketimine, as described previously.[37] Compound 32 (0.80 g; 5 mmol) in 20 ml dry ether was added dropwise to a stirred suspention of 0.38 g (10 mmol) of lithiumaluminium hydride in 10 ml of dry ether at 0°C. After removal of the cold bath, the reaction mixture was stirred overnight at room temperature, poured into ice water, acidified with HCl 2N and extracted with ether. The combined extracts were dried ($MgSO_4$), and evaporated in vacuo to afford 0.77 g (95%) of pure 27 as a colorless oil (purity > 98%; GLC).

^{1}H NMR (CCl_4) : 0.90 (9H,s,tBu); 2.31 (1H,s,broad,OH); 3.20 (1H,d,broad,J=6Hz,CH-O); 3.32 and 3.39 (each 3H,each s,2xOMe); 4.23 (1H,d,J=6Hz,CH(OMe)$_2$). IR (NaCl) : 3500 cm^{-1} (s; OH); 2840 cm^{-1} (m; OMe). Mass spectrum m/z (%) no M$^+$; 131(1); 130(2); 115(1); 99(2); 87(0.8); 85(0.7); 75(100); 74(9); 57(18).

Spectroscopic Data of the Reaction Products

2-t-Butyl-3-(1-methylethenyl)oxaziridine (26)

^{1}H NMR ($CDCl_3$) : 1.09 (9H,s,t-Bu); 1.65 (3H,m,CH_3); 4.19 (1H,s,N-CH-O); 5.18 and 5.30 (each 1H,each m,=CH_2). ^{13}C NMR ($CDCl_3$) : δ 15.63 (q,MeC=); 25.24 (q,Me_3); 57.83 (s,N-CMe_3); 75.78 (d,O-CH-N); 117.39 (t,CH_2=); 141.87 (s,C=CH_2). Mass spectrum m/z (%) : 141 (M$^+$; 3); 126(3); 99(2); 97(3); 86(11); 85(36); 84(22); 72(6); 70(7); 69(6); 57(100); 56(18); 43(36); 42(9); 41(50); 39(13).

Elemental analysis : 9.98% N found, 9.92% N calcd.

This compound could not be gas chromatographed on a packed column (decomposition) but was obtained with a purity of about 92% from dehydrobromination of oxaziridine 10.

N-t-Butyl 2,2-dichloro-3,3-dimethylbutanamide (28)

^{1}H NMR ($CDCl_3$) : 1.10 (9H,s,t-Bu); 1.35 (9H,s,N-t-Bu); NH invisible. IR (KBr) : 1665 cm^{-1} ($\nu_{C=O}$). Mass spectrum m/z (%) : no M$^+$; 205/7(1); 190/2(1); 149/51(15); 93/5(25); 69(5); 58(50); 57(100); 41(22).

N-t-Butyl 2,2-dimethylpropanamide (29)

^{1}H NMR ($CDCl_3$) : 1.18 (9H,s,t-Bu); 1.35 (9H,s,t-Bu); 5.3 (1H,br,NH). IR (NaCl/$CHCl_3$) : 1655 cm^{-1} ($\nu_{C=O}$); IR (KBr) : 1630 cm^{-1} ($\nu_{C=O}$). Mass spectrum m/z (%) : 157 (M$^+$; 13); 142(4); 101(6); 85(6); 57(100); 41(24). Mp. 90°C (subl.). This compound was identical in all aspects with an authentic sample prepared from trimethylacetyl chloride and t-butylamine in dichloromethane (1 h, RT).

t-Butyl isocyanide (33)

This compound was identical in all aspects with reported data.[41]

Methyl N-t-butyl dichloroacetimidate (34)

This compound had identical spectroscopic data to those described previously.[39]

2-(N-t-Butyl)amino-2-methylpropanal (38a) and 2-(N-cyclohexyl)amino-2-methylpropanal (38b) were identical in all aspects to the compounds previously obtained by an independent synthetic route.[52]

2,2-Dichloropentanal (44)
This compound was identical with an authentic sample.[33]

N-t-Butyl formamide (45)
This compound was identical in all aspects with a sample prepared from formic acid and t-butylamine.

1,1-Dichloro-3,3-dimethylpropane (46)
This dichloroalkane was identical to the compound previously obtained from the haloform-type reaction of 2,2-dichloro-3,3-dimethyl-1-phenyl-1-butanone with sodium methoxide in methanol.[38]

N-t-Butyl trichloroacetamide (50)
^{1}H NMR ($CDCl_3$) : δ 1.43 (9H,s,t-Bu); NH invisible. IR (NaCl/$CHCl_3$) 1712 cm^{-1} ($\nu_{C=O}$); 3410 and 3320 cm^{-1} (ν_{NH}). Mass spectrum m/z (%) no M^+; 202/4/6/8 (1%); 100(9); 84(2); 57(100); 42(13); 41(28); 40(6); 39(6). Mp. 112°C. This compound was identical in all aspects to authentic material prepared from trichloroacetyl chloride and t-butylamine.

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