Tetrahedron Letters No. 21, pp. 1761-1764, 1971. Pergamon Press. Printed in Great Britain.

IMINOSULFURANES (SULFILIMINES) III.[1]

THE PREPARATION AND PROPERTIES OF N-ACETYLIMINODIALKYLSULFURANES

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(Received in USA 24 March 1971; received in UK for publication 14 April 1971)

Although N-sulfonyliminosulfuranes have been prepared by many workers and their structures well established,[2,3] the preparation of N-acyliminodialkylsulfuranes (I), and their reactions and spectral characteristics, have not received such detailed study. Tarbell and Weaver[4] were the first workers to prepare iminosulfuranes containing a carbonyl group attached to nitrogen.

$$R_2\overset{\oplus}{S}-\overset{\ominus}{N}-COR' \qquad (I)$$

They prepared N-(chloroacetyl)iminosulfuranes Ia and Ib ($R=Et, -(CH_2)_4-$) by the reaction of sulfoxides with α-chloroacetamides in the presence of acetic anhydride, (scheme I).

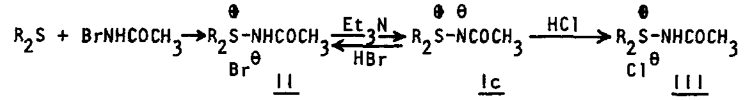
Scheme I $R_2SO + NH_2COCHCl_2 \xrightarrow{Ac_2O} R_2\overset{\oplus}{S}-\overset{\ominus}{N}COCHCl_2$ Ia $\quad R_2SO + NH_2COCCl_3 \longrightarrow R_2\overset{\oplus}{S}-\overset{\ominus}{N}COCCl_3$ Ib

Analogous iminosulfuranes have been prepared by the condensation of di- and tri-chloroacetylisocyanates with dimethylsulfoxide,[5] and by the reaction of α-dichloro- and α-dibromoacetamide with sulfides in the presence of sodium hypochlorite.[6] However, all of these reactions are confined to the preparation of N-(halogenoacetyl)iminosulfuranes. On the other hand, N-benzoyliminodimethylsulfurane (I, R=Me, R'=Ph) can be prepared by photolysis of 3-phenyl-Δ^2-1,4,2-dioxazolin-5-one in the presence of dimethylsulfide,[7] or by the reaction of N-chlorobenzimidate with dimethyl sulfide.[8] In 1947, Likhosherstov[9] reported that N-chloroacetamide reacts with dimethyl sulfide in 3.5:1 acetone/carbon tetrachloride to form crude N-acetyliminodimethylsulfonium chloride (90% yield). The salt was reported to decompose partially during recrystallization, and accordingly it could not be isolated pure. Treatment of the crude sulfonium salt with ammonia gave an oil, which was suspected to be N-acetyliminodimethylsulfurane, but it was not purified, and its structure was not established.

We report here the preparation of pure N-acetyliminodimethyl and N-acetyliminodiethylsulfuranes, Ic (scheme 2, R=Me,Et). Their structures were investigated by ir, uv, nmr and mass spectrometry, and the hydrolysis and thermolysis of the iminosulfuranes were also studied. This work forms part of our continuing investigations into the effect of the N-substituent on the nucleophilicity, basicity, stability, and general reactivity of iminosulfuranes.

1) Preparation and Properties of N-Acetyliminodialkylsulfuranes, and their derived Salts.

The synthetic route used is shown in scheme 2



$$R_2S + BrNHCOCH_3 \rightarrow \underset{\underline{II}}{\underset{Br^{\ominus}}{R_2\overset{\oplus}{S}\text{-}NHCOCH_3}} \underset{HBr}{\overset{Et_3N}{\rightleftarrows}} \underset{\underline{Ic}}{R_2\overset{\oplus}{S}\text{-}\overset{\ominus}{N}COCH_3} \xrightarrow{HCl} \underset{\underline{III}}{\underset{Cl^{\ominus}}{R_2\overset{\oplus}{S}\text{-}NHCOCH_3}}$$

Scheme 2

N-Acetyliminodimethylsulfonium bromide, II (R=Me) was obtained in 81% yield by adding dimethylsulfide, (1.2 moles) in CCl_4 to a suspension of N-bromoacetamide, (1.0 mole) in a mixture of acetone and CCl_4 at 0°. In CCl_4 alone reaction is very slow, and the presence of acetone (ca. 30%) is necessary for a moderate reaction rate. Prolonged reaction (>4 hours) leads to the formation of large amounts of acetamide hydrobromide. Ether or chloroform was unsatisfactory as a reaction solvent, since the main product obtained was acetamide hydrobromide. The sulfonium salt II (R=Me) is a white crystalline solid, mp 111-112° (d), and could be recrystallized from absolute alcohol without decomposition. Treatment of the sulfonium salt II (R=Me) with triethylamine (molar ratio 1:1.2) in methylene chloride at 0° afforded N-acetyliminodimethylsulfurane Ic (R=Me) in 78% yield. The ylid Ic (R=Me) is a deliquescent white crystalline solid, mp 67-68° (ex CCl_4); the sulfonium salt II (R=Me) could be recovered in 75% yield by treatment of the iminosulfurane Ic (R=Me) with aqueous HBr in acetone at 0°. N-Acetyliminodimethylsulfonium chloride, III (R=Me) was obtained in 79% yield by treatment of the ylid Ic (R=Me) with aqueous HCl in acetone at 0°. The salt had mp 132°-133° (d) (ex 1:3 $EtOH/Et_2O$), lit.[9] mp 78-90°.

The reaction of diethyl sulfide and N-bromoacetamide was carried out in a similar manner. N-Acetyliminodiethylsulfonium bromide, II (R=Et) was prepared in 67% yield; the salt had mp 110-111° (d), (ex 1:1 $EtOH/Et_2O$). Treatment of the sulfonium salt II (R=Et) with triethylamine gave the crude ylid Ic (R=Et), which was distilled to give pure N-acetyliminodiethylsulfurane, (81%, bp 110-111°/0.3 mm) a clear liquid. N-Acetyliminodiethylsulfonium chloride, III (R=Et) was prepared in 87% yield by the reaction of the ylid Ic (R=Et) with anhydrous HCl in ether at 0°. The salt had mp 116-117° (d) (ex 1:3 $EtOH/Et_2O$).

Hydrolysis of Iminosulfuranes. The ylids Ic (R=Me,Et) are soluble in water, and hydrolyse slowly at 20° to acetamide and dialkyl sulfoxide; the reaction is accelerated by potassium hydroxide. In contrast with this, N-benzoyliminodibenzylsulfurane is highly resistant to hydrolysis with hot aqueous alkali.[3]

2) Spectral Characteristics of N-Acetyliminodialkylsulfuranes, and their Salts.

The spectral data are summarized in Table I. In the ir spectra, the C=O stretching vibration of the sulfonium salts is at 1695-1705 cm^{-1}, while the iminosulfuranes have ν_{max} 1565-1570 cm^{-1}. This shift of 135-140 cm^{-1} in going from the salt to the ylid is slightly greater than that observed for the analogous N-ethoxycarbonyliminodialkylsulfuranes,[10] (105-120 cm^{-1}). The C-N stretching band also shifts to higher wavenumber (II/III$\rightarrow$Ic) which indicates that a stronger C-N bond is present in the iminosulfurane. In the sulfonium salts, there appear to be two bands associated with the S-N bond, while the ylids exhibit a single band at higher wavenumber. It is interesting to compare the spectra of N-(dichloroacetyl)iminosulfuranes (Ia), which show two bands at about 800 and 820 cm^{-1}, attributed to the S-N stretching vibration.[6] In the nmr spectra, the acetyl protons shift upfield by about 0.36 ppm in going from the sulfonium salt to the ylid, due to the delocalization of the negative charge on nitrogen. The chemical shifts of the methyl, and methylene protons attached to the positively charged sulfur atom are also shifted upfield (II/III Ic). The shift of ca. 0.7 ppm is very similar to that observed in the N-ethoxycarbonyl compounds,[10] and indicates that the sulfur atom in the iminosulfurane has a smaller positive charge than that in the salt. The implications of this spectral data with regard to the structure of N-acetyliminodialkylsulfuranes are summarized in scheme 3.

Table I. Spectral Characteristics of N-Acetyliminodialkylsulfuranes, and their Salts.*

		Ic (R=Me)	Ic (R=Et)	II (R=Me)	II (R=Et)	III (R=Me)	III (R=Et)
i.r. (cm^{-1})	NH stretch	-	-	2780	2750	2780	2750
	C=0	1565	1570	1695	1705	1695	1705
	C-N	1310	1305	1220	1210	1220	1210
	S-N	797	800	698,577	710,580	696,576	710,577
uv λ_{max}	(nm)	221	223	-	-	-	-
ε_{max}		4760	4910	-	-	-	-
nmr (δ)	CH_3CO	1.80s	1.83s	2.14s	2.22s	2.14s	2.21s
	$CH_3\overset{+}{S}$	2.64s	-	3.30s	-	3.28s	-
	$CH_3\underline{CH_2}\overset{+}{S}$	-	2.74-3.15m	-	3.68q	-	3.70q
	$\underline{CH_3}CH_2\overset{+}{S}$	-	1.19t	-	1.36t	-	1.35t

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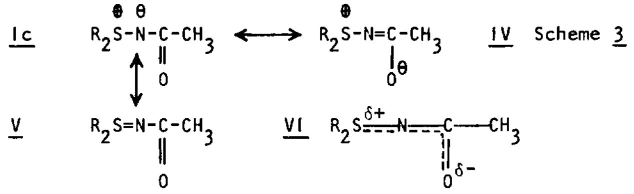
* Ir spectra were run as KBr discs, or liquid films (Ic, R=Et) using a Perkin-Elmer Model 225 grating infra-red spectrophotometer; uv spectra were performed with a Perkin-Elmer spectrometer Model 202, ca. 2.2 x 10^{-4} mole/l in EtOH, (absorption did not follow the Beer Lambert Law). Nmr spectra were obtained with a Varian A-60A spectrometer, using TMS as internal standard (δ=0.00); s-singlet, t-triplet, q-quartet, m-multiplet. The purity of the sulfonium salts II and III (R=Me,Et) was established by microanalysis, and the purity of the ylids Ic (R=Me,Et) was substantiated by mass spectrometry.



Scheme 3

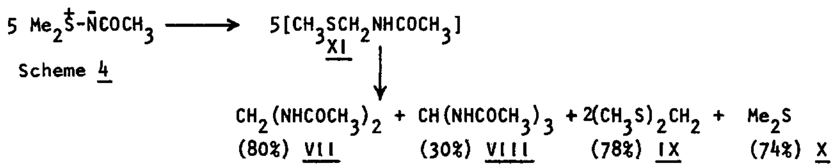
$$R_2\overset{\oplus}{S}-\overset{\ominus}{N}-\underset{\underset{O}{\parallel}}{C}-CH_3 \longleftrightarrow R_2\overset{\oplus}{S}-N=\underset{\underset{O^{\ominus}}{|}}{C}-CH_3$$

$$R_2S=N-\underset{\underset{O}{\parallel}}{C}-CH_3 \qquad R_2\overset{\delta+}{S}\text{---}N\text{---}\underset{\underset{O^{\delta-}}{\parallel}}{C}-CH_3$$

The ir spectra indicate that canonical form (IV) is a major contributor to the iminosulfurane structure, while form (V) is a relatively minor contributor. The nmr spectra reveal that the ylid possesses a smaller positive charge on sulfur, as compared with the salt, and thus the overall structure can be represented by (VI).

3) Thermolysis of N-Acetyliminodialkylsulfuranes.

Thermolysis of Ic (R=Me) at 120-125° for 24 hours gave 1,1-bis(N-acetylimino)methane (VII), 1,1,1-tris(N-acetylimino)methane (VIII), bis(methylthio)methane (IX) and dimethyl sulfide (X), (scheme 4, % yields in parentheses). It seems likely that N-(methylthiomethyl)acetamide (XI), formed from Ic (R=Me) by prototropy followed by a Stevens type rearrangement, is the primary intermediate.



Scheme 4

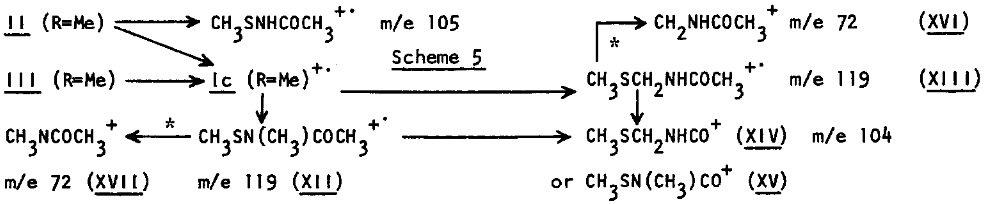
$$5\ \mathrm{Me_2\overset{+}{S}\text{-}\overset{-}{N}COCH_3} \longrightarrow 5[\mathrm{CH_3SCH_2NHCOCH_3}]\ \mathrm{XI}$$

$$\downarrow$$

$$\underset{(80\%)\ \mathrm{VII}}{\mathrm{CH_2(NHCOCH_3)_2}} + \underset{(30\%)\ \mathrm{VIII}}{\mathrm{CH(NHCOCH_3)_3}} + \underset{(78\%)\ \mathrm{IX}}{\mathrm{2(CH_3S)_2CH_2}} + \underset{(74\%)\ \mathrm{X}}{\mathrm{Me_2S}}$$

4) Mass Spectrometry of N-Acetyliminodialkylsulfuranes, and their derived Salts.

The fragmentation of the ylid Ic (R=Me), and the sulfonium chloride III (R=Me) is very similar (scheme 5). The primary cleavage of salt III (R=Me) is loss of HCl to give the ylid Ic (R=Me)$^{+\cdot}$, m/e 119, and the subsequent cleavage of the ion at m/e 104 (base peak) indicates that two structures are possible (XIV and/or XV). The genesis of the fragment at m/e 104 is loss of $CH_3^{\cdot}$ from m/e 119 (XII and/or XIII), which is formed by rearrangement of Ic (R=Me)$^{+\cdot}$. Subsequent loss of $CH_3S^{\cdot}$ from m/e 119 affords the ion at m/e 72 (XVI and/or XVII), which then eliminates ketene. The mass spectrum of the sulfonium bromide II (R=Me) is similar to that of the ylid Ic (R=Me) and the salt III (R=Me), except that in addition, loss of CH_3Br occurs to give the fragment at m/e 105 (r.a. 21), which eliminates ketene affording the ion at m/e 63 (base peak).



Scheme 5

$$\mathrm{II\ (R{=}Me)} \longrightarrow \mathrm{CH_3SNHCOCH_3}^{+\cdot}\ \ m/e\ 105$$

$$\mathrm{II\ (R{=}Me)},\ \mathrm{III\ (R{=}Me)} \longrightarrow \mathrm{Ic\ (R{=}Me)}^{+\cdot} \longrightarrow \mathrm{CH_3SCH_2NHCOCH_3}^{+\cdot}\ \ m/e\ 119\ \mathrm{(XIII)}$$

$$\mathrm{CH_3SCH_2NHCOCH_3}^{+\cdot} \xrightarrow{*} \mathrm{CH_2NHCOCH_3}^{+}\ \ m/e\ 72\ \mathrm{(XVI)}$$

$$\mathrm{CH_3SCH_2NHCOCH_3}^{+\cdot} \longrightarrow \mathrm{CH_3SCH_2NHCO^+}\ \mathrm{(XIV)}\ \ m/e\ 104\ \text{or}\ \mathrm{CH_3SN(CH_3)CO^+}\ \mathrm{(XV)}$$

$$\mathrm{Ic\ (R{=}Me)}^{+\cdot} \longrightarrow \underset{m/e\ 119\ \mathrm{(XII)}}{\mathrm{CH_3SN(CH_3)COCH_3}^{+\cdot}} \longrightarrow \mathrm{CH_3SCH_2NHCO^+}\ \mathrm{(XIV)}\ \ m/e\ 104$$

$$\underset{m/e\ 72\ \mathrm{(XVII)}}{\mathrm{CH_3NCOCH_3}^{+}} \xleftarrow{*} \mathrm{CH_3SN(CH_3)COCH_3}^{+\cdot}$$

In the mass spectrum of salt II (R=Et), the loss of EtBr, and of HBr from the molecular ion was observed; the latter cleavage afforded the ylid Ic (R=Et)$^{+\cdot}$ which then eliminated C_2H_4 to give the ion at m/e 119. It is interesting to compare the spectrum of N-ethoxycarbonyliminodiethylsulfurane,[10] which showed loss of C_2H_4 from the molecular ion in an analogous process.

Investigation of the thermolysis of the ylid Ic (R=Et), and the sulfonium salts (II and III), and the reactions of the ylids with electrophiles is currently being performed.

Acknowledgements: Supported in part by U.S.P.H.S. Grants CA-08793 and CA-07174 of the National Cancer Institute.

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