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The Reaction of *N*, *N′*-Sulfinyl-bisdialkylamines

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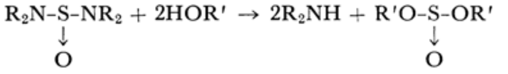
This paper describes reactions of *N*, *N′*-sulfinyl-bisdialkylamines (I) with alcohols, carboxylic acids and some electrophilic reagents. When I was refluxed in alcohols, corresponding dialkyl sulfites were obtained in good yields. The reaction of I with carboxylic acids gave *N*, *N*-dialkyl carboxylic amides (III), sulfur dioxide and dialkylamines. I reacts with acyl chlorides and carboxylic anhydrides to yield III and dialkylamine-*N*-sulfinyl chloride, and sulfur dioxide, respectively. On the other hand, I and aromatic aldehydes gave 1 : 1 adducts. Dialkylaminonitriles were obtained by the subsequent treatment of the adducts with potassium cyanide.

The reactions of *N*, *N′*-sulfinyl-bisdialkylamines (I) with active hydrogen compounds and some electrophilic reagents were studied in order to know the behavior of compounds having sulfur-nitrogen linkage. Concerning these compounds, the reactions of *N*, *N′*-sulfinyl-diimidazole with alcohols and carboxylic acids were recently reported by Staab.[1]

First, the reactions of I with active hydrogen compounds such as alcohols and carboxylic acids were attempted. *N*, *N′*-Sulfinyl-bisdimethylamine (Ia) did not react with ethanol at room temperature, but when Ia was refluxed in ethanol for 5 hr, diethyl sulfite was obtained in a 60% yield along with the evolution of dimethylamine. Dibutyl sulfite was obtained in a 37% yield when butanol was used instead of ethanol in the above experiment. The reaction of *N*, *N′*-sulfinylbisdiethylamine (Ib) with ethanol also gave diethyl sulfite and diethylamine.



$$R_2N\text{-}\underset{\overset{\downarrow}{O}}{S}\text{-}NR_2 + 2HOR' \rightarrow 2R_2NH + R'O\text{-}\underset{\overset{\downarrow}{O}}{S}\text{-}OR'$$

Ia $R=CH_3$
Ib $R=C_2H_5$

When a benzene solution of Ia and benzoic acid was refluxed for 2 hr, *N*, *N*-dimethylbenzamide was obtained in a 60% yield with the evolution of sulfur dioxide and dimethylamine. Similarly, *N*, *N*-dimethylacetamide was obtained in a 90% yield when Ia was treated with acetic acid. It may be assumed that *N*, *N*-dialkyl carboxylic

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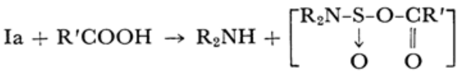
[1] H. A. Staab and K. Wendel, *Angew. Chem.*, **73**, 26 (1961).

amides (III) are produced through an initial formation of the mixed anhydrides (II) of dialkylamine-*N*-sulfinic acid and carboxylic acid, followed by the elimination of sulfur dioxide from II.



$$\mathrm{Ia + R'COOH \rightarrow R_2NH + \left[R_2N\text{-}\underset{\underset{O}{\downarrow}}{S}\text{-}O\text{-}\underset{\underset{O}{\|}}{C}R' \right]}$$

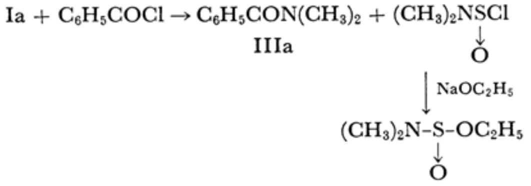
II

$\mathrm{II \rightarrow SO_2 + R'CN(CH_3)_2}$

IIIa $\mathrm{R'=C_6H_5}$
IIIb $\mathrm{R'=CH_3}$

In the next place, the reactions of I with electrophilic reagents such as benzoyl chloride, acid anhydrides and aldehydes were tried. It is known that I reacts with thionyl chloride[2] and dialkyl chloroborane[3] to give dialkylamine-*N*-sulfinyl chlorides, and dialkyl dialkylaminoborane and dialkylamine-*N*-sulfinyl chloride, respectively.

When Ia was treated with benzoyl chloride in dry ether at room temperature, IIIa was obtained in an 86% yield and the other product, dimethylamine-*N*-sulfinyl chloride was confirmed by the conversion into ethyl dimethylamine-*N*-sulfinate (80%) by the treatment with sodium ethoxide.



$$\mathrm{Ia + C_6H_5COCl \rightarrow \underset{IIIa}{C_6H_5CON(CH_3)_2} + (CH_3)_2N\underset{\underset{O}{\downarrow}}{S}Cl}$$

$$\Big\downarrow \mathrm{NaOC_2H_5}$$

$$\mathrm{(CH_3)_2N\text{-}\underset{\underset{O}{\downarrow}}{S}\text{-}OC_2H_5}$$

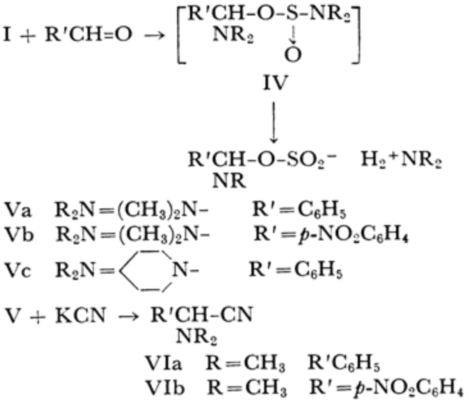
Similarly, nitrogen-sulfur bond-fission was occurred to give IIIa in an 85% yield along with the vigorous evolution of sulfur dioxide when a benzene solution of Ia and benzoic anhydride were refluxed for 3 hr. *N, N*-Diethylbenzamide (IIIc) and IIIb were also obtained in good yields when Ib and Ia were treated with benzoic anhydride and acetic anhydride, respectively.

$\mathrm{I + (R'CO)_2O \rightarrow 2R'CONR_2 + SO_2}$

IIIa $\mathrm{R=CH_3}$ $\mathrm{R'=C_6H_5}$
IIIb $\mathrm{R=R'=CH_3}$
IIIc $\mathrm{R=C_2H_5}$ $\mathrm{R'=C_6H_5}$

Further, the reactions of *N, N'*-sulfinyl-bisdialkylamines with aldehydes were attempted. When an ethereal solution of benzaldehyde was added to I at room temperature, an oily material was separated soon. It was found that the oily substance gave white crystals on standing overnight at room temperature or when a small amount of 99% alcohol was added. These white crystals were shown to be dimethylammonium salt of α-dimethylaminobenzyl sulfite (V) by means of its elemental analysis and its infrared absorption spectrum which has characteristic bands attributed to ammonium salt (2500—2800 cm^{-1}) and sulfinyl group (1200 cm^{-1}). This reaction can be explained that α-dimethylaminobenzyl dimethylamine-*N*-sulfinate (IV) was initially formed by the electrophilic attack of benzaldehyde to I, followed by the hydrolysis of unstable IV to give V. Similarly, dialkylammonium salts of sulfurous acid monoester were obtained when Ia was treated with *p*-nitrobenzaldehyde and *N, N'*-sulfinyl-bispiperizine (Ic) with benzaldehyde. These salts have similar structures to those of aldehyde-sodium bisulfite adducts and are expected to yield aminonitriles by the treatment with potassium cyanide.

Indeed, when a methanol solution of potassium cyanide was added to a suspension of Va in dry dioxane at room temperature, α-dimethylaminobenzyl cyanide (VIa) was obtained in a 70% yield as expectedly. Similarly, α-dimethylamino-*p*-nitrobenzyl cyanide (VIb) was obtained when Vb was treated with potassium cyanide.



$$\mathrm{I + R'CH{=}O \rightarrow \left[R'\underset{NR_2}{CH}\text{-}O\text{-}\underset{\underset{O}{\downarrow}}{S}\text{-}NR_2 \right]}$$

IV

$$\Big\downarrow$$

$$\mathrm{R'\underset{NR}{CH}\text{-}O\text{-}SO_2{}^- \quad H_2{}^+NR_2}$$

Va $\mathrm{R_2N=(CH_3)_2N\text{-}}$ $\mathrm{R'=C_6H_5}$
Vb $\mathrm{R_2N=(CH_3)_2N\text{-}}$ $\mathrm{R'=}p\mathrm{\text{-}NO_2C_6H_4}$
Vc $\mathrm{R_2N=}$ N- $\mathrm{R'=C_6H_5}$

$$\mathrm{V + KCN \rightarrow R'\underset{NR_2}{CH}\text{-}CN}$$

VIa $\mathrm{R=CH_3}$ $\mathrm{R'C_6H_5}$
VIb $\mathrm{R=CH_3}$ $\mathrm{R'=}p\mathrm{\text{-}NO_2C_6H_4}$

When Ia was added to acetone, the reaction started immediately and the reaction mixture became dark brown. But, no simple product could be isolated. No reaction was observed when Ia and acetophenone or benzophenone were refluxed for 5 hr in benzene, and the starting materials were recovered.

Now it was found that I and phenyl isocyanate, phenyl isothiocyanate or carbon disulfide gave 1 : 1 adducts which have betaine structures.[4] The reactions of the adducts will be described in the following paper.

Experimental

All melting and boiling points are uncorrected. *N, N*-Sulfinyl-bisdialkylamines were prepared according to the direction of Michaelis.[5]

Reaction of *N, N'*-Sulfinylbisdimethylamine (Ia) with Ethanol. *N, N*-Sulfinyl-bisdimethylamine (Ia) (1.36 g, 0.01 mol) was refluxed for 5 hr in 10 m*l* of

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2) G. Zinner and W. Kölling, *Naturwissenschaften*, **46**, 354 (1959).

3) H. Nöth and G. Mikulaschek, *Chem. Ber.*, **97**, 709 (1964).

4) T. Mukaiyama, H. Takei, H. Shimizu and M. Higo, *J. Org. Chem.*, to be submitted.

5) A. Michaelis, *Chem. Ber.*, **28**, 1015 (1895).

absolute ethanol. After removal of the excess ethanol, diethyl sulfite was obtained in a 60% yield (0.83 g), bp 70°C/10 mmHg.

Similarly, when *N*, *N*-sulfinyl-bisdiethylamine (Ib) (1.92 g, 0.01 mol) was used instead of Ia, diethyl sulfite was obtained in a 70% yield (0.97 g).

When Ia (1.36 g, 0.01 mol) was heated at 100°C for 5 hr in 10 m*l* of *n*-butanol, di-*n*-butyl sulfite was obtained in a 37% yield (0.70 g), bp 94°C/8 mmHg.

Reaction of Ia with Benzoic Acid. A solution of Ia (1.36 g, 0.01 mol) and benzoic acid (1.22 g, 0.01 mol) in dry benzene was refluxed for 3 hr. During the reaction period, the evolution of sulfur dioxide and dimethylamine was observed. After removal of the solvent, *N*, *N*-dimethylbenzamide (IIIa) was obtained in a 60% yield (0.90 g), bp 100—103°C/3 mmHg.

Similarly, when acetic acid (0.60 g, 0.01 mol) was used instead of benzoic acid, *N*, *N*-dimethylacetamide (IIIb) was obtained in a 90% yield (0.78 g), bp 48—50°C/12 mmHg.

Reaction of Ia with Benzoyl Chloride. To an ice-cooled solution of Ia (1.36 g, 0.01 mol) in benzene, a solution of benzoyl chloride (1.41 g, 0.01 mol) was added drop by drop with stirring. After the addition was complete, the reaction mixture was stirred continuously for half an hour at room temperature. Then to the mixture, a solution of sodium ethoxide (0.68 g, 0.01 mol) in ethanol was added. After removal of the precipitated sodium chloride by centrifugal separation and of the solvent under reduced pressure, the residue was distilled to give IIIa (1.28 g, 86%), and ethyl dimethylamine-*N*-sulfinate (1.10 g, 80%), bp 67—68°C/20 mmHg.

Reaction of Ia with Benzoic Anhydride. A solution of Ia (1.36 g, 0.01 mol) and benzoic anhydride (2.26 g, 0.01 mol) in dry benzene was refluxed for an hour. During the reaction period, vigorous evolution of sulfur dioxide was observed. After removal of the solvent, IIIb was obtained by distillation in an 80% yield (2.30 g).

In a similar way, reaction of Ia and acetic anhydride (1.02 g, 0.01 mol) gave *N*, *N*-dimethylacetamide (IIIb) (1.40 g, 80%), bp 58—60°C/2 mmHg. Ib (1.92 g, 0.01 mol) and benzoic anhydride (2.26 g, 0.01 mol) gave *N*, *N*-diethylbenzamide (IIIc) (2.40 g, 90%), bp 110°C/2 mmHg.

Reaction of Ia with Benzaldehyde. When an ethereal solution of benzaldehyde (1.06 g, 0.01 mol) was added drop by drop to an ice-cooled ethereal solution of Ia (1.36 g, 0.01 mol) with stirring, the reaction soon started and an oily substance began to deposit. After stirring for several hours at room temperature, the oily substance gradually solidified. The reaction mixture was allowed to stand overnight and then the precepitate (Va), 1.4 g (50%), was filtered and recrystallized three times from dry dioxane, mp 115°C (decomp.). The infrared spectrum (KBr) showed strong absorptions at 3400 (hydrate), 2500—2800 (ammonium salt) and 1200 cm^{-1} (sulfinate). Analytical data show that the crystals are monohydrates.

Found: C, 47.45; H, 7.67; N, 9.84%. Calcd for $C_{11}H_{20}O_3N_2S{\cdot}H_2O$: C, 47.43; H, 7.91; N, 10.06%.

Reaction of Ia with *p*-Nitrobenzaldehyde. A solution of *p*-nitrobenzaldehyde (1.51 g, 0.01 mol) in dry benzene was added to an ice-cooled solution of Ia (1.36 g, 0.01 mol) in dry benzene with stirring. The reaction mixture was allowed to stand overnight and then 99% ethanol was added. The resulting white precipitate (Vb), 2.50 g (80%), was filtered and recrystallized from ethanol, mp 140.5°C (decomp.). The infrared spectrum (KBr) showed strong absorptions at 3450 (hydrate), 2750—2550 (ammonium salt), 1553, 1355 (nitro group) and 1200 cm^{-1} (sulfinate).

Found: C, 41.61; H, 6.03; N, 12.98%. Calcd for $C_{11}H_{19}O_5N_3S{\cdot}H_2O$: C, 40.87; H, 6.50; N, 12.99%.

Reaction of *N*, *N*-Sulfinyl-bispiperidine (Ic) with Benzaldehyde. The procedure used here was virtually identical with the above experiment. The resulting white precipitate (Vc) (70%) was recrystallized from dry dioxane, mp 136—139°C (decomp.). The infrared spectrum (KBr) showed strong absorptions at 2750—2500 (ammonium salt) and 1200 cm^{-1} (sulfinate).

Found: C, 59.79; H, 8.29; N, 8.63%. Calcd for $C_{17}H_{28}O_3N_2S$: C, 59.98; H, 8.29; N, 8.23%.

Reaction of Dimethylammonium Salt of α-Dimethylaminobenzyl Sulfite (Va) with Potassium Cyanide. To a suspension of (Va) (2.7 g, 0.01 mol) in dry dioxane, a solution of potassium cyanide (1.30 g, 0.02 mol) in methanol was added drop by drop with stirring. After stirring for half an hour at room temperature, the precipitate was removed by centrifugal separation and the solvent was removed under reduced pressure. From the residue, α-dimethylaminobenzyl cyanide (VIa) was obtained by distillation in a 72% yield (1.15 g), bp 85—86°C/3 mmHg. The infrared spectrum of the distillate was identical with that of an authentic sample.

Similarly, reaction of (Vb) (1.6 g, 0.005 mol) and potassium cyanide gave α-dimethylamino-*p*-nitrobenzyl cyanide (VIb) (0.40 g, 40%), mp 118—119°C.

Found: C, 58.66; H, 5.11; N, 20.12%. Calcd for $C_{10}H_{11}O_2N_3$: C, 58.53; H, 5.37; N, 20.48%.