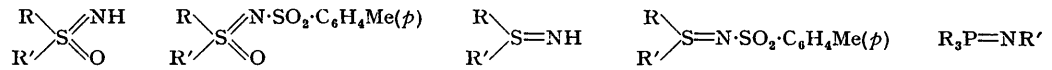
287. *Preparation and Properties of Some Aliphatic Sulphoximines.*

By J. K. Whitehead and H. R. Bentley.

A number of aliphatic sulphoximines have been synthesised by the alternative routes of the action of hydrazoic acid on the appropriate sulphides or sulphoxides in the presence of concentrated sulphuric acid and by the hydrolysis of toluene-*p*-sulphonylsulphoximides. It has been shown that the former reaction is of general application whereas the success of the latter method depends upon the state of substitution of the alkyl groups in the starting material.

Some reactions of sulphoximines are examined.

Dimethylsulphoximine (I; R = R′ = Me) was first synthesised by the hydrolysis of toluene-*p*-sulphonyldimethylsulphoximide (II; R = R′ = Me) by means of concentrated sulphuric acid (Bentley and Whitehead, *J.*, 1950, 2081). Bentley, McDermott, and Whitehead (*Nature*, 1950, **165**, 735; *Proc. Roy. Soc.*, 1951, *B*, **138**, 265) later synthesised dimethylsulphoximine by the action of hydrazoic acid on dimethyl sulphoxide. DL-Methionine and *S*-methyl-l-cysteine sulphoxides were also converted into the corresponding sulphoximines by the second route. These synthetic methods have now been extended in relation to certain aliphatic sulphoximines and some reactions of the latter have been examined.



(I) (II) (III) (IV) (V)

The nomenclature of these compounds is now presented on a logical basis. The name "sulphoximine" was earlier adopted (*J.*, 1950, 2081) for the series typified by (I), as an acceptable contraction of "sulphoxidimine" which follows logically by comparison with the phosphinimines (V). The naming of (II) as toluene-*p*-sulphonyldialkylsulphoximides then follows. Substance of type (III), of which the parent is unknown, have hitherto been called "dialkylsulphilimines" but are now named "dialkylsulphidimines" again by analogy with "phosphinimine"; compounds of type (IV), typical of the stable series of toluenesulphonated sulphilimines, then become "toluene-*p*-sulphonyldialkylsulphidimides" and not "dialkylsulphintoluene-*p*-sulphonylimines."

The preparation of sulphoximines by the isolation of the corresponding toluene-*p*-sulphonylsulphoxidimines, followed by hydrolysis of the toluene-*p*-sulphonylsulphoximides produced, is not a general reaction. On the other hand, the alternative synthesis by the action of hydrazoic acid on the corresponding sulphoxides appears to be of general application.

The S–N linkage in simple aliphatic sulphidimides is easily severed by dilute acids (Holloway, Kenyon, and Phillips, *J.*, 1928, 3000). Substitution in the alkyl groups appears to weaken this linkage still further. Previous results indicate that sulphidimines cannot be formed from heavily substituted sulphides. For instance, Mann and Pope (*J.*, 1922, **121**, 1052) were unable to prepare sulphidimides from derivatives of diethyl sulphide containing more than two chlorine atoms, and Tarbell and Weaver (*J. Amer. Chem. Soc.*, 1941, **63**, 2939) were unable to condense bis-2-hydroxyethyl sulphoxide with toluene-*p*-sulphonamide although a hydrated sulphidimide does result from the action of chloramine-T on the corresponding sulphide. Further, neither methionine nor its sulphoxide gives a sulphidimide when treated with chloramine-T and with toluene-*p*-sulphonamide respectively (Bentley, McDermott, and Whitehead, *loc. cit.*, 1951). We have now prepared the sulphidimides (IV; R = Me, R′ = CH_2·CH_2Cl or CH_2·CH_2·OH) from 2-chloroethyl and 2-hydroxyethyl methyl sulphide, respectively.

The stability of the S=N bond in sulphidimides under oxidising conditions is the limiting factor in attempts to extend the synthesis of sulphoximides by oxidation of the former with permanganate. Oxidation of (IV; R = Me, R′ = CH_2·CH_2Cl or CH_2·CH_2·OH) with

potassium permanganate in water, aqueous sodium hydroxide, or acetic acid gave toluene-*p*-sulphonamide in each case; with potassium permanganate or perhydrol in acetone, the appropriate sulphidimide is recovered unchanged. The alternative synthesis of sulphoximides by use of hydrazoic acid involves the formation of a nitrogen bond to a sulphur atom already carrying an oxygen atom. This appears to be a general reaction throughout the range of compounds studied. Diethyl-, methyl-*n*-propyl-, and *n*-butyl-methyl-sulphoximines are formed from the appropriate sulphoxides by this method, and Misani, Fair, and Reiner (*J. Amer. Chem. Soc.*, 1951, **73**, 459) have prepared diamyl-sulphoximine and several aromatic sulphoximines by the same route.

The increased stability of the S–N bond on a sulphur atom also carrying an oxygen atom is further illustrated by the extreme resistance of the sulphoximines to hydrolysis by acid. The bond, however, is readily broken by oxidising agents, as in the oxidation of methioninesulphoximine to methionine sulphone by perhydrol (Misani and Reiner, *Arch. Biochem.*, 1950, **27**, 234). It is also broken by nitrous acid, and dimethylsulphoximine is readily converted into dimethyl sulphone by this reagent.

Sulphoximines can also be prepared by the action of hydrazoic acid directly on the corresponding sulphide; *e.g.*, dimethyl sulphide with 2 mols. of hydrazoic acid in chloroform and concentrated sulphuric acid gives a product from which both dimethyl sulphoxide and dimethylsulphoximine can be recovered; under the same conditions also, methionine is converted directly into its sulphoximine. A sulphide and hydrazoic acid probably give first the unstable sulphidimine (III), but we could not isolate such a derivative which must therefore be hydrolysed at once to the sulphoxide which then reacts normally with a further molecule of hydrazoic acid.

Sulphoximines are more basic than the corresponding sulphoxides but otherwise resemble them closely in physical properties. In the final mixture produced in the hydrazoic acid synthesis partition between the two layers is greater in the acid layer for the sulphoximine and in the chloroform layer for untreated sulphoxide. Partition is, however, by no means complete in either case. The only crystalline salts of sulphoximines which we have obtained are picrates which are useful for characterisation.

Dimethylsulphoximine and sodium in an inert solvent form the unstable hygroscopic *N*-sodio-derivative, the structure of which follows from its ready reaction with toluene-*p*-sulphonyl chloride to give toluene-*p*-sulphonyldimethylsulphoximide.

Experimental

Diethylsulphoximine.—Under conditions described by Bentley, McDermott, and Whitehead (*loc. cit.*, 1951), diethyl sulphoxide (7·7 g.), sodium azide (5·6 g.), and sulphuric acid (*d* 1·84; 25 ml.) in chloroform (100 ml.) gave *diethylsulphoximine* (3·3 g., 49%) as a colourless oil, b. p. 135—140° (bath-temp.)/0·1 mm. (Found: C, 39·5; H, 9·4. $C_4H_{11}ONS$ requires C, 39·4; H, 9·1%); the *picrate* had m. p. 122—123° (Found: C, 34·6; H, 4·3; N, 16·0. $C_4H_{11}ONS,C_6H_3O_7N_3$ requires C, 34·3; H, 4·3; N, 16·0%).

Methyl-n-*propylsulphoximine.*—Similarly, methyl *n*-propyl sulphoxide (5·0 g.), sodium azide (3·1 g., 1·2 mols.), and sulphuric acid (*d* 1·84; 15 ml.) in chloroform (75 ml.) give *methyl*-n-*propylsulphoximine* (2·3 g., 13%), b. p. 180—185° (bath-temp.)/0·1 mm. (Found: C, 39·2; H, 9·2. $C_4H_{11}ONS$ requires C, 39·4; H, 9·1%) [*picrate*, m. p. 112° (Found: C, 34·2; H, 4·0; N, 15·9. $C_4H_{11}ONS,C_6H_3O_7N_3$ requires C, 34·3; H, 4·3; N, 16·0%)].

n-*Butylmethylsulphoximine.*—Similarly, *n*-butyl methyl sulphoxide (30·0 g.), sodium azide (19·5 g., 1·2 mols.), and sulphuric acid (*d* 1·84; 90 ml.) in chloroform (450 ml.) gave this sulphoximine as an oil which could not be distilled without decomposition; its *picrate* had m. p. 118° (Found: C, 36·5; H, 4·6; N, 15·5. $C_5H_{13}ONS,C_6H_3O_7N_3$ requires C, 36·2; H, 4·7; N, 15·4%).

Toluene-p-*sulphonyl*-2-*chloroethylmethylsulphidimide.*—2-Chloroethyl methyl sulphide (11·0 g.) was shaken with a solution of chloramine-T (23·0 g., 1 mol.) in water (200 ml.) until precipitation was complete. The product (23·0 g., 82%) was collected, washed with water, and recrystallised from ethanol, giving the *sulphidimide* as small needles, m. p. 124° (Found: C, 43·1; H, 5·1; N, 5·15. $C_{10}H_{14}O_2NClS_2$ requires C, 42·9; H, 5·0; N, 5·0%).

Toluene-p-*sulphonyl*-2-*hydroxyethylmethylsulphidimide.*—2-Hydroxyethyl methyl sulphide (9·2 g.) and chloramine-T (23·0 g., 1 mol.) were dissolved in the minimum of hot ethanol; the

solution was kept for 30 minutes, filtered from sodium chloride, and concentrated. The solid product was collected and recrystallised from benzene, giving the *sulphidimide* (16·0 g., 61%) as clusters of rods, m. p. 108° (Found: C, 45·8; H, 5·7; N, 5·15. $C_{10}H_{15}O_3NS_2$ requires C, 46·0; H, 5·75; N, 5·4%).

Attempted Oxidations.—Oxidation of these derivatives with potassium permanganate (1 or 2 mols.) in water, aqueous sodium hydroxide, or acetic acid gave toluene-*p*-sulphonamide. The sulphidimides were recovered unchanged after treatment with potassium permanganate (5 mols.) or perhydrol (1 mol.) in boiling acetone.

Dimethylsulphoximine.—Sodium azide (40·0 g., 2 mols.) was added in small portions during 6 hours to a vigorously stirred mixture of dimethyl sulphide (20·0 g.), sulphuric acid (*d* 1·84; 75 ml.), and chloroform (200 ml.) kept at 40° in a flask fitted with a reflux condenser. The product finally recovered from the aqueous acid layer (Bentley, McDermott, and Whitehead, *loc. cit.*) was distilled, giving dimethyl sulphoxide (2·0 g.), b. p. 92—95°/20 mm. (Found: C, 31·3; H, 8·0. Calc. for C_2H_6OS: C, 30·8; H, 7·7%), and dimethylsulphoximine (3·3 g.), b. p. 155—160°/20 mm. (picrate, m. p. 179° alone or mixed with an authentic specimen).

Methionine Sulphoximine.—Under similar conditions DL-methionine (5·0 g.), sodium azide (4·7 g., 2·4 mols.), and sulphuric acid (*d* 1·84; 30 ml.) in chloroform (100 ml.) gave DL-methionine sulphoximine (1·8 g., 27%), m. p. 219° alone or mixed with an authentic sample, identical with an authentic specimen on paper chromatograms (phenol and acetone).

N-*Sodio-dimethylsulphoximine.*—A solution of dimethylsulphoximine (0·25 g.) in dry benzene (25 ml.) was boiled under reflux with finely divided sodium (0·10 g.) until reaction had ceased. Unchanged sodium was removed mechanically from the suspension of yellow sodio-derivative, and toluene-*p*-sulphonyl chloride (0·3 g.) was then added to the mixture. After 30 minutes' refluxing, during which time sodium chloride slowly separated, the mixture was evaporated to dryness, hot water (10 ml.) was added to the residue, and the hot solution filtered; the cooled filtrate finally deposited needles, m. p. 167—169° alone or mixed with an authentic specimen of toluene-*p*-sulphonyldimethylsulphoximide.

Deamination of Dimethylsulphoximine.—Solutions of sodium nitrite (1·6 g.) in water (50 ml.) and of hydrochloric acid (*d* 1·18; 2·5 ml.) in water (50 ml.) were added together dropwise with stirring to a solution of dimethylsulphoximine (2·0 g.) in water (50 ml.) and hydrochloric acid (*d* 1·18; 2·5 ml.) at 75—80°. The final solution was evaporated to dryness under reduced pressure, the residue was redissolved in water (10 ml.), again evaporated, and then dissolved in water (20 ml.), and the solution extracted with ether (2 × 20 ml.). Unchanged dimethylsulphoximine (picrate, m. p. 179° alone or with an authentic specimen) was recovered from the ethereal extract. The aqueous fraction was evaporated to dryness under reduced pressure, the dry residue was extracted with acetone, and the acetone-soluble product was distilled, giving dimethyl sulphone, b. p. 170—180°/20 mm., m. p. 103—104° (Found: C, 26·0; H, 6·7. Calc. for $C_2H_6O_2S$: C, 25·5; H, 6·4%).

RESEARCH ASSOCIATION OF BRITISH FLOUR MILLERS, CEREALS RESEARCH STATION, OLD LONDON ROAD, ST. ALBANS, HERTS.
ROYAL TECHNICAL COLLEGE, GLASGOW.
[*Received, December 21st,* 1951.]