312. *Urea and Related Compounds. Part V.* Some Sulphenylthioureas.*

By Frederick Kurzer and W. Tertiuk.

S-Alkyl-*N*-arylsulphenyl- and *S*-alkyl-*NN*′-diarylsulphenyl-*iso*thioureas are obtained in fair yields by the interaction of *iso*thioureas and appropriate quantities of a sulphenyl chloride.

Previous Parts[1] of this series have dealt with the synthesis and properties of sulphenylureas. We now describe the results of parallel experiments with thioureas.

In general, the sulphenylthioureas were more difficult to prepare and more labile than the urea analogues. Of several reactions[1] that afford sulphenylureas, only one proved suitable in the thiourea series. Interaction of an *iso*thiourea (I; $R = Me, CH_2Ph$) with appropriate quantities of *o*-nitrobenzenesulphenyl chloride in the presence of alkali in water–acetone gave, as main products, *S*-alkyl-*N*-arylsulphenyl- (II; $R = Me, CH_2Ph$; $R' = o\text{-}NO_2{\cdot}C_6H_4$) or *S*-alkyl-*NN*′-diarylsulphenyl-*iso*thioureas (III; $R = Me, CH_2Ph$; $R' = o\text{-}NO_2{\cdot}C_6H_4$). The former were converted into the latter by more sulphenyl halide.

$$\underset{\text{(I)}}{NH_2{\cdot}C(SR){:}NH} \xrightarrow{R'SCl} \underset{\text{(II)}}{R'S{\cdot}NH{\cdot}C(SR){:}NH} \xrightarrow{R'SCl} \underset{\text{(III)}}{R'S{\cdot}NH{\cdot}C(SR){:}N{\cdot}SR'}$$

The success of these condensations depended on careful control to reduce side reactions resulting in rapid loss of sulphenyl chloride as disulphide ($R'S{\cdot}SR'$) or thiolsulphonate ($R'SO_2{\cdot}SR'$) (cf. Experimental). The assigned structures of products (II) and (III) are based on composition, molecular weights, and mode of formation and reasoning previously detailed[1] in respect of analogous sulphenyl*iso*ureas. The identity of the substituted *iso*thioureas (II, III) and *iso*ureas (IV, V) is further reflected in their remarkably brilliant colours: monosulphenyl derivatives were scarlet, and disulphenyl derivatives ($R' = o\text{-}NO_2{\cdot}C_6H_4$) orange-red in both series.

$$\text{(IV)}\quad R'S{\cdot}NH{\cdot}C(OR){:}NH \qquad R'S{\cdot}NH{\cdot}C(OR){:}N{\cdot}SR'\quad \text{(V)}$$

Sulphenyl*iso*thioureas (II, III), though stable as solids, were considerably more labile than the corresponding ureas; they were rapidly hydrolysed by acids and alkalis, and

---

* Part IV, *J.*, 1957, 4461.

[1] Kurzer, *J.*, 1953, 549, 3360.

deposited diaryl disulphide (R′S·SR′) slowly even from solutions in non-polar solvents. Dealkylation, which is readily accomplished with sulphenyl*iso*ureas [1] (IV, V), failed with the sulphur analogues: both mono- and di-sulphenyl*iso*thioureas (II, III) were rapidly converted into diaryl disulphide under the most restrained conditions, by Fairfull, Low, and Peak's general method.[2] It is evident that the replacement of the oxygen by the sulphur atom considerably weakens the link between sulphur and nitrogen in the resulting sulphenyl compounds (II, III). This may also explain our inability to synthesise sulphenylthioureas by methods (cf. Experimental) that had previously been found suitable [1] in the preparation of sulphenylureas.

EXPERIMENTAL

S-*Methyl*-N-o-*nitrobenzenesulphenyl*iso*thiourea*.—A solution of *S*-methyl*iso*thiuronium sulphate (5·56 g., 0·04 mole) in water (20 ml.) was diluted with acetone (120 ml.). The resulting precipitate dissolved on addition of 3N-sodium hydroxide (6·7 ml., 0·02 mole); the stirred liquid was then treated dropwise during 1—1½ hr. at 0—8° with *o*-nitrobenzenesulphenyl chloride [3] (6·65 g., 0·035 mole) in acetone (50 ml.) and simultaneously with 3N-sodium hydroxide (13·3 ml., 0·04 mole), at a rate to keep the mixture just alkaline (no alkali was needed during the first 10—15 min.; traces of methanethiol were liberated). The resulting suspension was made just acid with 1—2 drops of dilute hydrochloric acid and set aside at room temperature for 1 hr., and the solid filtered off and rinsed with a few drops of acetone (solid R). Spontaneous evaporation of the filtrate at room temperature gave a deep scarlet residue, which was rinsed with a little water, and allowed to drain and dry. It was dissolved in successive portions of cold acetone (2 × 15; 2 × 10 ml.), the solution decanted from a little undissolved solid S, and the solvent allowed to evaporate. A solution of the residue in warm benzene (6 × 5 ml.) slowly deposited deep-scarlet crystals (2·95—3·8 g.; 35—45%); a further crystallisation from benzene–light petroleum gave S-*methyl*-N-o-*nitrobenzenesulphenyl*iso*thiourea*, scarlet prisms, m. p. 108—110° [Found: C, 39·7; H, 4·2; N, 17·0; S, 25·8%; *M* (cryoscopically, in thymol), 225. $C_8H_9O_2N_3S_2$ requires C, 39·5; H, 3·7; N, 17·3; S, 26·3%; *M*, 243].

Residue R (3—4 g.) was mainly inorganic; it was suspended in water (100 ml.), and the undissolved orange solid (0·2—0·5 g.) collected and crystallised from acetone or benzene, giving di-*o*-nitrophenyl disulphide, m. p. and mixed m. p. 196—197°. In some experiments the residue R consisted of the disulphenyl*iso*thiourea, m. p. and mixed m. p. 153—155° (see below). Solid S was impure di-*o*-nitrophenyl disulphide.

In experiments employing quicker addition (20—30 min.), mono- and di-sulphenylated (see below) *iso*thiourea were produced together (in approx. 20 and 15% yield, respectively) and were separated by fractional crystallisation from benzene, the monosubstituted product separating first. In one experiment, the *NN′*-disubstituted *iso*thiourea was formed almost exclusively.

S-*Methyl*-NN′-*di*-o-*nitrobenzenesulphenyl*iso*thiourea*.—(*a*) A stirred solution of *S*-methyl*iso*thiourea (0·04 mole; prepared as above) was treated during 1½—2 hr. at 0—8° with the acid chloride (17 g., 0·09 mole) and 3N-sodium hydroxide (23·3 ml., 0·07 mole). The precipitate (T) was removed and the filtrate allowed to evaporate at room temperature. The separate aqueous layer was decanted from the red residue, which was rinsed with water, drained, and dried. Crystallisation from hot benzene (12 ml. per g.) gave prisms (m. p. 150—152°; 6·35 g., 40%); further crystallisation from benzene and from acetone gave S-*methyl*-NN′-*di*-o-*nitrobenzenesulphenyl*iso*thiourea*, m. p. 153—155° (Found: C, 42·6, 42·7; H, 3·1, 3·0; N, 13·8; S, 23·8%; *M* (cryoscopically in naphthalene), 375. $C_{14}H_{12}O_4N_4S_3$ requires C, 42·4; H, 3·0; N, 14·1; S, 24·2%; *M*, 396). When crystallised from benzene only, the product had the same m. p., but gave high analyses for carbon. The final mother-liquors (acetone) contained small quantities of monosulphenylated *iso*thiourea. Solid T consisted of much inorganic material mixed mainly with di-*o*-nitrophenyl disulphide (up to 4·15 g., 30%).

In experiments in which the 3N-alkali was added at a rate which kept the mixture alkaline,

---

[2] Fairfull, Low, and Peak, *J.*, 1952, 742.

[3] Bogert and Stull, *Org. Synth.*, Coll. Vol. I, 1941, p. 220; Hubacher, *ibid.*, Coll. Vol. II, 1943, p. 455.

the granular precipitate afforded up to 10% of (III; R = Me; R′ = *o*-$NO_2\cdot C_6H_4$). The added sulphenyl chloride reappeared mostly as *o*-nitrophenyl *o*-nitrobenzenethiolsulphonate (50%), yellow platelets, m. p. and mixed m. p. 139—141° (from benzene). (Found: C, 42·2; H, 2·6; N, 8·0; S, 18·3. Calc. for $C_{12}H_8O_6N_2S_2$: C, 42·35; H, 2·35; N, 8·2; S, 18·8%).

(*b*) *S*-Methyl-*N*-*o*-nitrobenzenesulphenyl*iso*thiourea (1·22 g., 0·005 mole) in acetone (10 ml.) was treated with sulphenyl chloride (0·006 mole)–N-sodium hydroxide (0·006 mole) during 90 min. The product, isolated and fractionated as before, gave up to 66% yields of the disulphenyl derivative, m. p. and mixed m. p. 153—154°.

Attempted demethylation of *S*-methyl-*N*-*o*-nitrobenzenesulphenyl- or *S*-methyl-*NN*′-di-*o*-nitrobenzenesulphenyl-*iso*thiourea by Fairfull, Low, and Peak's method [2] gave dark liquids (within 5—8 min.), from which only di-*o*-nitrophenyl disulphide, m. p. and mixed m. p. 197—198°, could be isolated (in 60 and 50% yield, respectively).

S-*Benzyl*-N-o-*nitrobenzenesulphenyl*iso*thiourea*.—A solution of *S*-benzyl*iso*thiuronium chloride (4·05 g., 0·02 mole) in warm water (15 ml.) was diluted with acetone (60 ml.) and cooled, and 3N-sodium hydroxide (3·3 ml., 0·01 mole) added. The stirred clear liquid was treated during 1 hr. with *o*-nitrobenzenesulphenyl chloride (0·015 mole) and 3N-sodium hydroxide (0·015 mole) in the usual way, the mixture being kept just alkaline. The deep-red solution was set aside to evaporate at room temperature, the resulting aqueous layer decanted, and the solid crystallised twice from benzene, and once from 1 : 1 acetone–benzene giving dark scarlet scales of S-*benzyl*-N-o-*nitrobenzenesulphenyl*iso*thiourea* (25 g.; 52%), m. p. 111—113° (Found: C, 52·7; H, 4·2; N, 13·1; S, 19·8. $C_{14}H_{13}O_2N_3S_2$ requires C, 52·7; H, 4·1; N, 13·2; S, 20·1%).

S-*Benzyl*-NN′-*di*-o-*nitrobenzenesulphenyl*iso*thiourea*.—Interaction of *S*-benzyl*iso*thiourea (0·02 mole.; water–acetone–alkali), *o*-nitrobenzenesulphenyl chloride (0·06 mole), and 3N-alkali (0·06 mole) during 2 hr. (as described immediately above) gave two phases containing much suspended solid, which was collected after storage overnight (Filtrate, F). After being washed with cold water and dried, the solid was crystallised from boiling benzene (25 ml.) (yield, 5·30 g., 56%) and then from acetone (10 ml.) giving orange-red prisms of S-*benzyl*-NN′-*di*-o-*nitrobenzenesulphenyl*iso*thiourea*, m. p. 146—148° (Found: C, 50·9; H, 3·4; N, 11·8; S, 20·7; $C_{20}H_{16}O_4N_4S_3$ requires C, 50·8; H, 3·4; N, 11·9; S, 20·3%). Evaporation of the deep-red layer of filtrate F gave small quantities of the disulphide (R′S·SR′) and more disulphenylated thiourea (6—12%).

The following experiments gave di-*o*-nitrophenyl disulphide as main product (% recovery in parentheses): (i—iv) Interaction of *o*-nitrobenzenesulphenamide [4] and phenyl *iso*thiocyanate (1·5 mole or large excess) in triethylamine (used as solvent or in catalytic quantities) at 95° during 1·5 hr. (60—75%); interaction of *o*-nitrobenzenesulphenyl chloride and (v) phenylthiourea (1 mole) in boiling benzene (80%), or (vi) thiourea (1·5 mole) in pyridine at 75° (during 30 min.) (90%); *o*-nitrobenzenesulphenamide was recovered (88%) after treatment with phenyl *iso*thiocyanate in the presence of sodium (1 equiv.) previously dissolved in acetone (15 min. at b. p. of solvent).

We thank the Council of the Chemical Society for a grant from the Research Fund.

Royal Free Hospital School of Medicine,
(University of London), W.C.1.

[*Received, October* 31*st*, 1957.]

---

[4] Zincke and Farr, *Annalen*, 1912, **391**, 55, 75.