34. *The Action of Chlorine on Aryl Thiocarbimides and the Reactions of Aryl* iso*Cyanodichlorides.*

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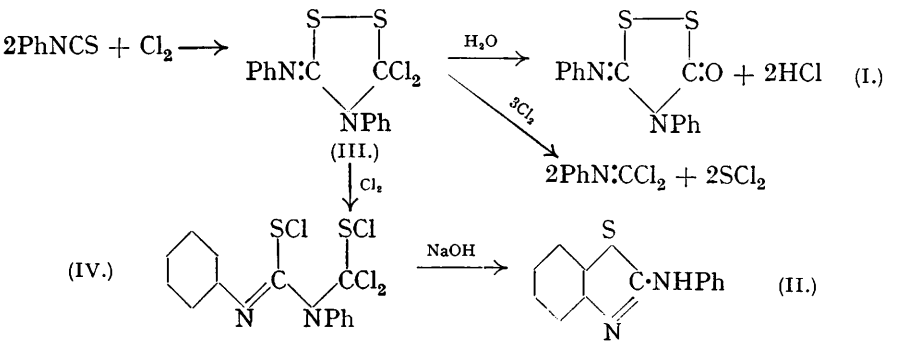
The reaction between aryl thiocarbimides and chlorine yields heterocyclic disulphides and *iso*cyanodichlorides. The decomposition and hydrolysis of the intermediate compounds to arylaminobenzthiazoles and the value of the *iso*cyanodichlorides in synthesising guanidines have been examined.

Sell and Zierold (*Ber.*, 1874, **7**, 1228) showed that phenyl thiocarbimide in chloroform is converted by chlorine into phenyl *iso*cyanodichloride and sulphur dichloride. In repeating this work, Helmers (*Ber.*, 1887, **20**, 786) observed the formation of a white precipitate, apparently an intermediate stage in the above reaction, to which he assigned the formula $(PhNCS)_2Cl_2$, based on its reaction with both alcohol and water to form bis(phenylthiocarbimide) oxide, $(PhNCS)_2O$, and with hydrogen sulphide to form thiocarbanilide. He obtained analogous reactions with *p*-tolyl thiocarbimide.

Freund (*Annalen*, 1895, **285**, 154) obtained bis(phenylthiocarbimide) oxide by the action of bromine on phenyl thiocarbimide and demonstrated its similarity in structure to perthiocyanic acid. Later the substance was assigned the structure (I) by Fromm and Heyder (*Ber.*, 1909, **42**, 3800).

We have extended the investigations of Helmers to a representative series of thiocarbimides and find that the separation of the intermediate compounds does not always take place, and in those cases where separation does occur, the amount is always very small. By altering the conditions of reaction a large amount of solid material can be obtained; this, however, is a new substance, which does not give the oxide on treatment with alcohol, but on reaction with caustic soda gives 1-anilinobenzthiazole (II).

It is possible to order all the above observations into the following scheme:



Of the substances formulated, all have accepted constitutions except (III) and (IV); that of (III) has been established by empirical analysis and by its reactions, but the extreme instability of the compound precludes a more precise determination; (IV) is a hypothetical intermediate.

Nef (*Annalen*, 1892, **270**, 282) claimed that phenyl *iso*cyanodichloride as prepared by Sell and Zierold contained *p*-chlorophenyl *iso*cyanodichloride, but this was not confirmed by Bly, Perkins, and Lewis (*J. Amer. Chem. Soc.*, 1922, **44**, 2896), who, by using phenyl *iso*cyanodichloride itself as the solvent in place of chloroform, obtained a pure product. Dennstedt (*Ber.*, 1880, **13**, 228) prepared *p*-bromophenyl *iso*cyanodichloride by Sell and Zierold's method and Bly obtained, together with other products, *p*-chlorophenyl and 2 : 4-dichlorophenyl *iso*cyanodichlorides by the action of thionyl chloride and chlorine on formanilide. Of the substituted phenyl thiocarbimides examined by us, only *o*-nitrophenyl thiocarbimide failed to yield the corresponding *iso*cyanodichloride. In this case, the product decomposed with explosive violence when the solvent used in the reaction was being distilled off on the water-bath.

The action of chlorine on the naphthyl thiocarbimides is being investigated.

Action of Acetic Acid on the iso*Cyanodichlorides*.—Sell and Zierold, by acting on phenyl *iso*cyanodichloride with glacial acetic acid, obtained acetanilide. They identified acetyl chloride as a product of the reaction and suggested the equations :

$$(1)\ PhN{:}CCl_2 + AcOH \longrightarrow HCl + AcCl + PhNCO$$
$$(2)\ PhNCO + AcOH \longrightarrow PhNHAc + CO_2$$

They did not isolate or observe the formation of phenyl *iso*cyanate.

We have shown that phenyl *iso*cyanate is not an intermediate in the above reaction, but that diphenylurea is first formed and then, under the action of the acetyl chloride produced, breaks down to form acetanilide :

$$(1)\ 2PhN{:}CCl_2 + 3AcOH \longrightarrow PhNH{\cdot}CO{\cdot}NHPh + CO_2 + HCl + 3AcCl$$
$$(2)\ PhNH{\cdot}CO{\cdot}NHPh + AcCl + AcOH \longrightarrow 2PhNHAc + CO_2 + HCl$$

This is proved by the isolation of substantial quantities of *s*-diphenylurea in the first stage of the above reaction, and by the fact that *s*-diphenylurea is only very slowly hydrolysed to acetanilide by acetic acid alone, whereas in the presence of acetyl chloride the reaction is rapid and proceeds to completion.

The behaviour of the other *iso*cyanodichlorides is analogous with the above, except that *m*-tolyl *iso*cyanodichloride yields an intermediate nitrogenous compound, m. p. 278°, of unknown constitution.

Primary Amines and iso*Cyanodichlorides*.—Sell and Zierold (*loc. cit.*), by gently warming a mixture of phenyl *iso*cyanodichloride and aniline, obtained a yellow-brown resin, which crystallised from aqueous alcohol in small white plates. On treatment with ammonia, the above compound yielded a white resinous mass which could not be purified. They suggested that the white crystalline compound was an isomer of triphenylguanidine, m.p. 207°. Nef (*loc. cit.*) allowed phenyl *iso*cyanodichloride to react with aniline and obtained triphenylguanidine hydrochloride, m.p. 241°. Dennstedt (*loc. cit.*) treated *p*-bromophenyl *iso*cyanodichloride with *p*-bromoaniline and obtained tri-*p*-bromophenylguanidine hydrochloride, from which he failed to isolate the free base.

We have extended the above investigations to a representative series of *iso*cyanodichlorides and primary amines, and found that a guanidine hydrochloride is always obtained, from which the base can usually be isolated :

$$RN{:}CCl_2 + 3R'NH_2 \longrightarrow RN{:}C(NHR')_2{,}HCl + R'NH_2{,}HCl$$

The method constitutes a simple approach to the unsymmetrical guanidines.

Experimental.

Phenyl thiocarbimide (400 g.) was prepared from thiocarbanilide (1100 g.) by the method of Bly, Perkins, and Lewis (*loc. cit.*). *o*-, *m*-, and *p*-Nitrophenyl thiocarbimides were prepared as follows : The nitroaniline (150 g.) was dissolved in hot concentrated hydrochloric acid (750 ml.), and water (6 l.) at 50° added, followed by thiocarbonyl chloride (125 g.) in 15 g. portions at

10-minute intervals. After 5 hours' stirring, the product was collected and recrystallised from dilute acetone. Yields, 100—130 g. *o*-Nitrophenyl thiocarbimide was photosensitive, changing from yellow through green to black when left for a few hours in sunlight and becoming yellow again in the dark. The other thiocarbimides used in this work were prepared by Dyson and George's method (J., 1924, **125**, 1702).

Bis(phenylthiocarbimide) Oxide.—Phenyl thiocarbimide (20 g.) in chloroform (64 g.) was slowly treated with chlorine without cooling until the increase in weight was 2 g. and solid commenced to appear. After ½ hour the solid was collected and dissolved in warm alcohol; yellow needles, m. p. 118°, crystallised (Found : N, 10·1. Calc. for $C_{14}H_{10}ON_2S_2$: N, 9·8%).

The following analogues were prepared (all formed yellow needles) : p-*tolyl*, m. p. 139° (Found : N, 9·2. $C_{16}H_{14}ON_2S_2$ requires N, 8·9%); m-*tolyl*, m. p. 128° (Found : N, 9·0%); p-*bromophenyl* (Found : S, 14·6; N, 6·5. $C_{14}H_8ON_2Br_2S_2$ requires S, 14·5; N, 6·3%).

No oxides were obtained from *o*-tolyl, *o*-, *m*-, and *p*-nitrophenyl thiocarbimides.

1-*Anilinobenzthiazole.*—(a) Phenyl thiocarbimide (20 g.) in chloroform (10 g.) was treated with chlorine until the increase in weight was 7 g. After 12 hours, the solid was collected, boiled with 40% sodium hydroxide solution for 5 minutes, and crystallised from alcohol and then from dilute acetic acid. The product formed long needles, m. p. 159° (Found : C, 69·1; H, 4·4; N, 12·6; S, 14·4. Calc. for $C_{13}H_{10}N_2S$: C, 69·0; H, 4·4; N, 12·4; S, 14·1%). The picrate formed yellow needles, m. p. 221°.

(b) Thiocarbanilide (4·5 g.), suspended in chloroform (50 ml.), was mixed with bromine (3·2 g.) in chloroform (10 ml.) and boiled for ½ hour; much hydrogen bromide was evolved. On cooling and standing, red needles of a bromo-addition product were deposited. These were suspended in sulphurous acid and reduced with sulphur dioxide; the product tended to form a sticky mass. The solid eventually obtained was treated with hot 2N-sodium hydroxide, and the base crystallised from ethyl acetate; m. p. 157°.

Phenyl iso*Cyanodichloride.*—This was prepared by Sell and Zierold's method (*loc. cit.*), phenyl *iso*cyanodichloride itself, however, being used as solvent. Phenyl thiocarbimide (318 g.) in phenyl *iso*cyanodichloride (289 g.) was treated with chlorine with cooling for 8 hours. The increase in weight was 363 g. The resulting liquid was freed from sulphur dichloride by distillation, and the phenyl *iso*cyanodichloride fractionated twice, the portion, b. p. 209—211°, being collected as a colourless oil, $d^{15°}$ 1·285; yield, 256 g. (Found : N, 8·2. Calc. for $C_7H_5NCl_2$: N, 8·05%).

The following analogues were prepared by treatment with chlorine in 2—3 times their weight of carbon disulphide and purified by fractionation under reduced pressure. All were colourless or pale yellow, lachrymatory oils, with unpleasant odours.

*iso*Cyanodichloride.	B. p.	$d^{15°}$.	N %, theo.	N %, found.
p-Bromophenyl	122—124°/15 mm.	1·5	5·5	5·5
p-Anisyl	155—160/15 mm.	1·5	—	—
p-Tolyl	121—124/20 mm.	1·2	7·4	7·4
m-Tolyl	130/10 mm.	1·35	7·4	7·2
o-Tolyl	125—130/15 mm.	1·3	7·4	7·3

m- *and* p-*Nitrophenyl* iso*Cyanodichlorides.*—The corresponding thiocarbimides, being very sparingly soluble in carbon disulphide, were dissolved in four times their weight of warm chloroform. The filtered solutions became cloudy on cooling, but soon cleared when chlorine was passed into them. *m*-Nitrophenyl *iso*cyanodichloride was distilled under reduced pressure; the portion, b. p. 165—170°/15 mm., set solid on cooling and then crystallised from ligroin in pale yellow, rhombic crystals, m. p. 68°. p-*Nitrophenyl* iso*cyanodichloride*, crystallised twice from ligroin, had m. p. 80° (Found : N, 13·3. $C_7H_4O_2N_2Cl_2$ requires N, 13·1%).

s-*Diphenylurea.*—Phenyl *iso*cyanodichloride (5 g.) and acetic acid (3·5 g.) in benzene (20 ml.) were refluxed for 2 hours. The benzene was removed by distillation, and the solid crystallised from alcohol; it formed long needles, m. p. 238° (subl.) alone or mixed with authentic *s*-diphenylurea.

The *p*-tolyl and *o*-tolyl analogues, m. p. 260° and 245° respectively, were prepared.

Acetanilide.—Phenyl *iso*cyanodichloride (10 g.), acetic acid (25 ml.), and benzene (50 ml.) were refluxed for 10 hours; much hydrogen chloride was evolved. The benzene was distilled off, and the acetic acid neutralised with 40% sodium hydroxide solution. The liberated oil set solid on cooling; recrystallised from water, it had m. p. 113°, alone or mixed with authentic acetanilide. Yield, 5 g.

Aceto-*p*-toluidide, m. p. 147°, aceto-*m*-toluidide, m. p. 65°, and aceto-*o*-toluidide, m. p. 109°, were prepared.

p-*Bromophenyl* iso*Cyanodichloride and Acetic Acid.*—*p*-Bromophenyl *iso*cyanodichloride (10 g.) and acetic acid (25 ml.) in benzene (50 ml.) were boiled together for 5 hours. Long colourless needles, m. p. and mixed m. p. with *s*-di-*p*-bromophenylurea 300°, separated on cooling. After a further 20 hours' boiling, some *s*-di-*p*-bromophenylurea still remained and was filtered off. The benzene was distilled from the filtrate, and acetic acid neutralised with 40% sodium hydroxide solution. The oil obtained quickly became solid; it formed needles, m. p. and mixed m. p. with authentic *p*-bromoacetanilide 170°, from dilute alcohol.

m-*Nitrophenyl* iso*Cyanodichloride and Acetic Acid.*—*m*-Nitrophenyl *iso*cyanodichloride (5 g.) and acetic acid (15 ml.) in benzene (25 ml.), after 5 hours' boiling, gave yellow needles, m. p. 246° after recrystallisation from alcohol (*s*-di-*m*-nitrophenylurea has m. p. 248°). After 20 hours' boiling, the residual urea was removed, benzene distilled off, and the acetic acid solution kept overnight; *m*-nitroacetanilide, m. p. 150°, mixed m. p. with an authentic specimen 149°, crystallised.

Triphenylguanidine.—Phenyl *iso*cyanodichloride (5 g.), aniline (10 g.), and benzene (100 ml.) were boiled under reflux for 16 hours. The crystalline solid which separated was filtered off, digested with hot concentrated hydrochloric acid, and allowed to cool. The triphenylguanidine hydrochloride thus obtained was crystallised from water; m. p. 241—242°, mixed m. p. with an authentic sample 240°. The base, liberated from a solution of the hydrochloride by means of ammonia and crystallised from alcohol, had m. p. 144°.

The following analogues were prepared:

Guanidine.	M. p. of hydrochloride.	M. p. of guanidine.	% Cl in hydrochloride. Found.	Theo.
Phenyldi-*p*-tolyl	222—223°	109°	10·4	10·1
Phenyldi-*m*-tolyl	206	93	10·2	10·1
Phenyldi-*o*-tolyl	205	100	10·2	10·1
Phenyldi-*p*-bromophenyl	257—262	Oil	7·5	7·4
p-Tolyldiphenyl	230	128	10·6	10·5
Tri-*p*-tolyl	231	125	9·6	9·7
p-Tolyldi-*p*-bromophenyl	262—266	178	7·2	7·2
Tri-*m*-tolyl	221	107	9·4	9·7
m-Tolyldi-*p*-tolyl	218	105	9·7	9·7
Tri-*o*-tolyl	213—215	129	9·7	9·7
o-Tolyldi-*p*-tolyl	205—208	87	9·6	9·7
Tri-*p*-bromophenyl	270—276 (decomp.)	126	—	—
p-Bromophenyldi-*p*-tolyl	251	123	—	—
m-Nitrophenyldi-*p*-tolyl	201—205	179	9·3	9·0
m-Nitrophenyldi-*m*-tolyl	218—225	139	9·2	9·0

The hydrochlorides are all white crystalline solids. The nitroguanidines are orange-yellow, the others colourless.

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