ARYLATION OF N,N'-DIPHENYLTHIOUREA WITH ARYLDIAZONIUM FLUOBORATES

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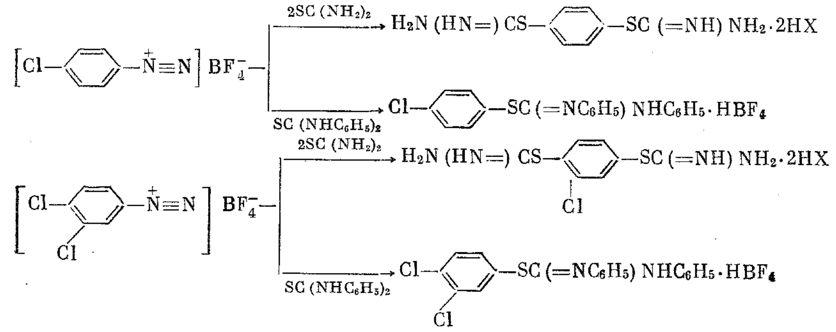
Recently we proposed a new method for the synthesis of S-arylisothiuronium compounds by the arylation of thiourea with aryldiazonium fluoborates according to the scheme:

$$ArN_2 \cdot BF_4 + SC(NH_2)_2 \rightarrow ArSC(=NH)NH_2 \cdot HBF_4 + N_2 .$$

This reaction proved to be a general method for the synthesis of aromatic isothiuronium compounds, containing various substituents in the ring [1, 2].

In the present paper is described the arylation of N,N'-diphenylthiourea with aryldiazonium fluoborates, leading to the synthesis of S-aryl-substituted derivatives of N,N'-diphenylthiourea. Up to now the synthesis of a number of members of this class of compounds was accomplished by the reaction of N,N'-diphenylthiourea with aryldiazonium chlorides in either alkaline or neutral medium [3, 4]. The same as in the case of thiourea [1], we investigated the arylation of N,N'-diphenylthiourea with aryldiazonium fluoborates, which contained various substituents in the ring, and specifically electron-donor (CH_3O), electron-acceptor (NO_2), and chlorine atoms in the o- and p-positions to the diazonium group. In this way were obtained the S-aryl-substituted derivatives of N,N'-diphenylthiourea, containing the nitro group and chlorine atoms in various positions in the ring.

We detected important differences in the behavior of thiourea and N,N-diphenylthiourea in the studied reaction. Thus, in contrast to thiourea, N,N'-diphenylthiourea when reacted with aryldiazonium fluoborates, containing chlorine in the p-position, replaces only the diazonium grouping. This makes it possible to synthesize S-aryl-substituted derivatives of N,N'-diphenylthiourea, containing chlorine atoms in the ring in the p-position to the isothiuronium group



In contrast to thiourea, N,N'-diphenylthiourea is not arylated by a p-methoxyaryldiazonium fluoborate, and does not replace the halogen atom in 2,4-dinitrochlorobenzene by the isothiuronium group. This behavior of N,N'-diphenylthiourea is probably explained by the fact that, when compared with thiourea, it is a less powerful nucleophilic reagent.

The S-aryl-substituted derivatives of N,N'-diphenylthiourea were isolated by us both as the free bases and as the salts, and specifically as the picrates, nitrates, and chlorides. It should be mentioned that the free bases proved to be quite stable compounds, and their melting point remained constant when

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TABLE 1

Obtained compounds	mp, °C	Yield, % of theory	Found, %			Calc., %		
			C	H	S	C	H	S
o-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5$	76—78	70	67,11	4,51	9,34	67,34	4,46	9,46
o-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5 \cdot Picr$	217—218	70 *	52,94	3,22 †		52,86	3,19	
o-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5 \cdot HNO_3$	105				8,04			7,98
o-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5 \cdot HCl$	184—186				8,75			8,54
o-$ClC_6H_4SC(=NH)NH_2 \cdot CH_3CH_2COOH$	125—126	Quantitative	46,19	5,32	12,32	46,06	5,02	12,29
o-$ClC_6H_4SC(=NH)NH_2 \cdot HOOC(CH_2)_2COOH$	130—131	"			13,51			13,05
o-$ClC_6H_4SC(=NH)NH_2 \cdot CH_3C_6H_4SO_3H$	90—93	"			17,39			17,87
p-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5$	86—87	30	67,96	4,58	9,32	67,34	4,46	9,46
p-$ClC_6H_4SC(=NC_6H_5)NHC_6H_5 \cdot Picr$	188—189	30 *			5,44			5,64
$3,4$-$Cl_2C_6H_3SC(=NC_6H_5)NHC_6H_5 \cdot Picr$	170—172	80 *	49,81	2,68	5,41	49,84	2,84	5,32
$O_2N—C_6H_4SC(=NC_6H_5)NHC_6H_5$	128—130	45	64,72	4,28	9,51	65,30	4,32	9,17
$O_2N—C_6H_4SC(=NC_6H_5)NHC_6H_5.Picr$	162—164	45 *			5,47			5,57

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* The yields of the salts are given, which were calculated on the basis of the amount of aryldiazonium fluoborate taken for reaction. When obtaining the salts from the free bases the yields were quantitative.

†Found: Cl 6. 87; 6. 65%; calculated: Cl 6,24%

they were allowed to stand in the air for a week. On the example of S-(o-chlorophenyl)isothiuronium chloride it was shown by us that the salts of the S-aryl-substituted derivatives of thiourea can be used to identify both carboxylic and sulfonic acids; the salts deposit immediately, in quantitative yield, and have quite high and distinct melting points.

EXPERIMENTAL METHOD

Reaction of N,N'-Diphenylthiourea with o-Chlorophenyldiazonium Fluoborate. To a stirred solution of 2.3 g of N,N'-diphenylthiourea in 25 ml of acetone, heated up to 40-50°C, was added in portions 2.3 g of anhydrous o-chlorophenyldiazonium fluoborate. At the end of gas evolution the reaction mixture was allowed to stand for 1 h and then it was divided into two portions.

The S-o-Chlorophenyl(N,N'-diphenyl)isothiuronium Free Base ($o\text{-}ClC_6H_4SC(=NC_6H_5)NHC_6H_5$). This was obtained by adding water to half of the reaction mixture until a precipitate ceased to deposit. At times the free base deposits as an oil. The oil crystallizes after 2-3 days. The obtained product was recrystallized from absolute alcohol.

The S-o-Chlorophenyl(N,N'-diphenyl)isothiuronium Picrate ($o\text{-}ClC_6H_4SC(=NC_6H_5)NHC_6H_5C_6H_2(NO_2)_3 \cdot OH$). This was obtained from the second half of the reaction mixture after removing the acetone. The obtained product was recrystallized from a mixture of alcohol and dimethylformamide. S-o-Chlorophenyl-(N,N'-diphenyl)isothiuronium picrate was also obtained from the free base. The mixed melting point of the two picrates was not depressed.

S-o-Chlorophenyl(N,N'-diphenyl)isothiuronium Nitrate. The nitrate was obtained by adding 2 ml of HNO_3 (d = 1.40) to 0.4 g of the o-chlorophenyl(N,N'-diphenyl)isothiuronium free base. The nitrate, which deposited as an oil, crystallized after several days. The product was recrystallized from alcohol.

S-o-Chlorophenyl(N,N'-diphenyl)isothiuronium Chloride. The chloride was obtained by adding 5-6 ml of 6% HCl solution to 0.4 g of the free base. The precipitate that deposited after a week was filtered, dissolved in alcohol, and precipitated with water.

Similar to the above described experiments were obtained the p-chlorophenyl- and p-nitrophenyl-(N,N'-diphenyl)isothiuronium free bases and picrates, and the 3,4-dichlorophenyl(N,N'-diphenyl)isothiuronium picrate. The obtained free bases and salts, their yields, melting points, and analyses are given in Table 1.

S-(o-Chlorophenyl)isothiuronium Propionate. To a solution of 0.4 g of CH_3CH_2COOH in water was added $NaHCO_3$ until neutral to litmus, and then was added an aqueous solution of 1 g of S-(o-chlorophenyl)-isothiuronium chloride. A precipitate of the S-(o-chlorophenyl)isothiuronium propionate deposited immediately, which was recrystallized from alcohol. S-(o-Chlorophenyl)isothiuronium succinate and the p-toluenesulfonate were obtained in a similar manner. The obtained salts, their melting points, analyses, and yields are given in Table 1.

CONCLUSIONS

1. Some S-aryl-substituted derivatives of N,N'-diphenylthiourea were synthesized by the arylation of N,N'-diphenylthiourea with aryldiazonium fluoborates.

2. The obtained S-aryl-substituted derivatives of N,N'-diphenylthiourea were isolated as the free bases and as the salts (chlorides, nitrates, and picrates).

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