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IODINE MEDIATED SYNTHESIS AND CONSTRUCTION OF AROMATIC THIOUREAS FROM AMINES

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ABSTRACT

A new facile methodology for the synthesis of aromatic thioureas by desulphurization and addition reaction of the required amine, carbon disulphide and ammonia solution in the presence of DMSO solvent using iron at room temperature. The structures of the synthesized compounds were confirmed by IR, and, ¹H-NMR methods. The synthetic benefits of the presented methods are reflected in the operational simplicity, mild reaction conditions, short reaction times, high purity and yield of the products. Considering the commercial importance of thioureas, it should be emphasized that implementation of the optimal synthesis of thiourea determined good intermediate for the synthesis heterocyclic compounds having good biological activity from amines using iodine as a reagent.

INTRODUCTION

Thiourea is a very important functional group and good intermediate for the synthesis heterocyclic compounds such as benzothiazole,^[1] iminothiazolines,^[2] thiohydantoins,^[3] 1,3,5-triazines,^[4] 2-amino-oxazolidines^[5] and other compounds such as minoxidil^[6] and herbicides,^[7] which have biological activity. In addition, thioureas are useful precursors in the synthesis of pharmaceutically important heterocycles⁸ and *N*-alkyl or *N*-aryl imides.^[9] Many methods for the synthesis of thioureas have been reported, for example, *N*-substituted thioureas are commonly prepared from the reaction of amines with alkali metal thiocyanates in the presence of a strong acid,^[10] aryl isothiocyanates with amines followed by basic hydrolysis,^[11] isothiocyanates with ammonia or amines in two step reactions,^[12] unsubstituted thioureas with primary amines with carbon disulfide in the presence of mercury acetate aqueous ammonia, primary alkyl amines at high temperature,^[13] and disubstituted cyanamides with hydrogen chloride and hydrogen sulfide in the presence of ammonia.

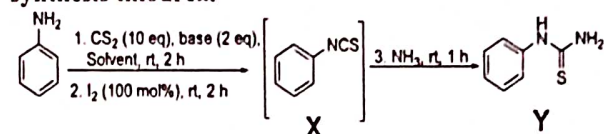
Several new methods for the preparation of substituted thioureas have been recently reported.^[14] Apart from previous reports still mild, efficient and environment friendly method is desired. Therefore, we wish to demonstrate the construction of thioureas from amines using cheap and readily available iodine as reagent.

EXPERIMENTAL SECTION

Herein, we report a three-component reaction between amine, CS₂ and ammonia solution in the presence of

DMSO solvent using iron at room temperature. The optimization of the reaction conditions was carried out with aniline as model substrate using different bases, solvents and iodine at varied temperatures (Table 1). The best result was obtained when the reaction was pursued at room temperature using 1 eq of the Iodine with bases like Et₃N, Sodium acetate and NaHCO₃ in the presence of DMF affording the phenylthiourea (Scheme 1) in 95% conversion (Table 1, entries 5 & 101-11).

Table 1: Optimization reaction conditions for the synthesis thiourea.



Entry	Solvent	Base	Yield (%)
1	Ethanol	Et ₃ N	45
2	Ethyl acetate	Et ₃ N	80
3	DCM	Et ₃ N	75
4	DMSO	Et ₃ N	75
5	DMF	Et ₃ N	95
6	H ₂ O	Et ₃ N	ND
7	n-Hexane	Et ₃ N	ND
8	n-Heptane	Et ₃ N	ND
9	DMF	Pyridine	55
10	DMF	NaHCO ₃	95
11	DMF	NaOAc	95
12	DMF	Na ₂ HPO ₄	95
13	DMF	NaOAc	67
14	-	-	ND

^aReaction conditions: Aniline (2 mmol), CS₂ (10 eq), Et₃N (2 eq), I₂ (100 mol%), Ammonia solution (2 ml) were stirred at room temperature in the presence of respective solvent for 5 h.

Firstly, the reaction was checked in the presence of different solvents. Among the solvents DMF gave target product in excellent yield. Other solvents like ethyl acetate, ethanol, DCM and DMSO could give target product in good yield. We have also examined with polar greenery solvent H₂O and no product was observed. Later we have checked with the non-polar solvents like n-Hexane and n-Heptane. Unfortunately, no non-polar solvent could give target product. The reaction with another organic base pyridine couldn't give expected product. However, the inorganic bases sodium bicarbonate, sodium acetate and disodium phosphate could give target products in good yield. Finally, the less amount of reagent like 50 mol % was examined, however the reaction to provide target product in moderate yield. The control experiment is confirmed that the reaction doesn't provide final product in the absence of solvent and base, and the starting material is recovered intact.

Having the optimal conditions in hand, we explored the scope of this procedure for the substrates having electron

donating and electron withdrawing substituents on the aryl rings. In this connection the various substrates bearing electron donating and electron withdrawing groups were examined under the standard reaction conditions (Table 2). The phenyl ring having electron donating groups such as 4-methyl, 4-methoxy could give their respective aromatic thioureas (Table 2, entries 3-4) in high yield. The unsubstituted phenyl ring also gave target product in quantitative yield (table 2, entry 1). Electron withdrawing groups such as 4-fluoro and 4-chloro substituents gave their final products in 75-84% yield (Table 2, entries 2 and 7). The aryl ring having strong electron withdrawing group -NO₂ on second position gave no product (table 2, entry 6). 4-Cyano aniline activity was also examined under optimized reaction conditions, but unfortunately no reaction was observed. Later, the same reaction was tested using strong base, anhydrous potassium hydroxide (KOH) and no target product could observe. Subsequent optimization for the reaction led to increase in yield, we did the reaction with anhydrous potassium hydroxide (KOH) at 80 °C. Very interestingly the reaction could produce target product in moderate yield (Table 2, entry 10). Di-substituted and ortho-substituted aryl rings could obtain their respective thioureas in good yield (Table 2, entries 5 and 8).

Table 2: Substrate scope for the synthesis thiourea.

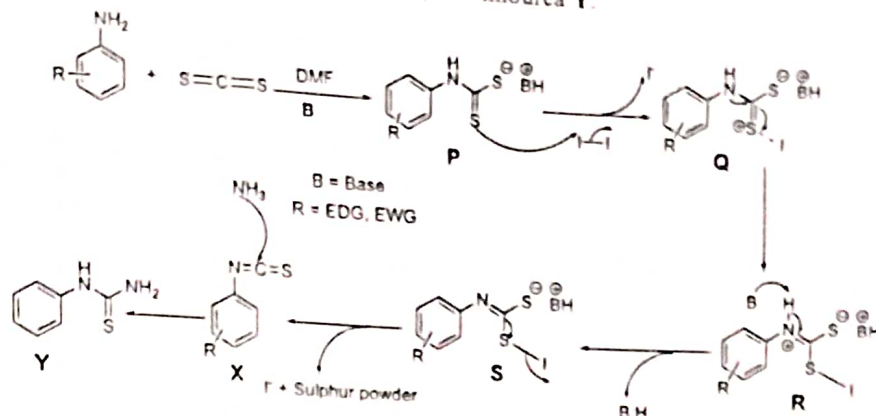
$ \begin{array}{c} \text{NH}_2 \\ \\ \text{R}-\text{C}_6\text{H}_4 \\ \xrightarrow[3. \text{NH}_3, \text{rt}, 1 \text{ h}]{1. \text{CS}_2 (10 \text{ eq}), \text{NaOAc} (2 \text{ eq}), \text{DMF}, \text{rt}, 2 \text{ h}; 2. \text{I}_2 (100 \text{ mol\%}), \text{rt}, 2 \text{ h}} \\ \text{R}-\text{C}_6\text{H}_4-\text{NH}-\text{C}(=\text{S})-\text{NH}_2 \end{array} $			
entry	Substrate	Product	Isolated yield (%) ^a
1			95
2			84
3			95
4			92
5			62
6			ND ^b
7			75
8			87
9			88
10			65 ^b
11			88
12			82

^aCompounds were confirmed by both IR and ¹H NMR analysis. ^b Base (KOH (1 eq)) and temp 85 °C were used.

MECHANISM OF THE REACTION

The mechanism of formation for phenyl thiourea from aniline is shown in below Scheme 1. The experimental evidence and from the literature report the mechanism proposed. As we shown in scheme 1, aniline (1) reacts with carbon disulphide in the presence of base (Et_3N)

and respective solvent to give thiocarbamate salt P. It may co-ordinate with iodonium and followed by remove the proton to afford the intermediate S via intermediate complexes Q and R. Desulfurization of S afforded diisocyanato X that reacts with ammonium to give target thiourea Y.



RESULT AND CONCLUSION

In conclusion, we have developed neat, clean and efficient methodology for the synthesis of aromatic thioureas. This reaction involved consecutive desulphurization and addition. The reactions are rapid and facile and accomplished under mild reaction conditions. All the reactions readily underwent optimized conditions to provide target products in moderate to excellent yield.

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