

The Preparation of S-Alkylthiuronium Picrates and a New Method for the Estimation of *tertiary* Alcohols

LENNART SCHOTTE and STIG VEIBEL

*Laboratory of Organic Chemistry, Chemical Institute, University of Uppsala, Sweden
and Department of Organic Chemistry, University of Technology, Copenhagen, Denmark*

In a recent paper one of us (L.S.¹) published an investigation of S-alkylthiuronium picrates and styphnates and found in accordance with Wild² that tertiary alkyl halides behave anomalously when refluxed with thiourea in ethanolic or methanolic solution, S-ethyl or -methyl thiuronium picrate being formed instead of S-*tertiary* alkylthiuronium picrate when the reaction mixture is treated with picric acid. This is probably due to a rapid reaction between the tertiary alkyl halide and the solvent by a S₁-mechanism, proceeding more rapidly than the reaction between the tertiary alkyl halide and thiourea and yielding a tertiary alcohol and the alkyl halide corresponding to the solvent alcohol, which then reacts with thiourea giving the primary alkyl derivative. Using the corresponding tertiary alcohols as solvents, however, the preparation of S-*tertiary* alkylthiuronium picrates was successful¹.

At the same time the other of us (S.V.) investigated the possibility of characterising tertiary alcohols as S-alkylthiuronium picrates, converting the tertiary alcohols into halides by shaking 1 vol. of the alcohol with 5 vol. of concentrated hydrochloric acid or constant boiling hydrobromic acid for some minutes, separating the non-aqueous layer and using it as alkyl halide. When preliminary experiments proved successful we agreed upon a common investigation of the reaction, the main difference between the techniques used by us being that one of us was using absolute ethanol or methanol, the other 35—80 % ethanol as a solvent, 35 % ethanol being used for the lower tertiary alkyl halides, 65 % or 80 % ethanol for the higher members of this series.

The general procedure used now has been: 1.52 g (0.02 mole) of thiourea are dissolved in 4 ml of water. 3 ml of ethanol and 0.02 mole of alkyl halide are added and the mixture is refluxed on the steam bath until the alkyl halide-layer has disappeared and 15 min. further (usually 2—3 hours); (*cf.* the preparation of S-benzylthiuronium chloride, Veibel and Lillelund³).

In some instances it was not possible to reach the point where the non-aqueous layer disappeared completely, possibly because the alcohol had not been completely converted into alkyl halide. In such cases the refluxing was continued for 5 hours and then interrupted.

The refluxed solution is poured into 200—300 ml of a 1 % aqueous solution of picric acid. A precipitate of the S-alkylthiuronium picrate was formed instantaneously. After $\frac{1}{2}$ hour the precipitate was isolated by suction and recrystallised from ethanol or dilute ethanol. Usually one recrystallisation suffices for getting analytically pure picrates.

Table 1 gives a summary of the alcohols examined. In the table is indicated when standard procedure has been followed and when more ethanol than the 3 ml prescribed for the standard procedure has been used. Besides, the table indicates the time of refluxing and the yield obtained.

In other experiments the possibility of substituting 4 ml of concentrated hydrochloric acid for the 4 ml of water prescribed for the standard procedure and 0.02 mole of the carbinol for 0.02 mole of the alkyl halide was examined.

Table 1. Preparation of S-alkylthiuronium picrates from tertiary alcohols.

Alcohol	Procedure	Time of reflux min.	Yield %	Radical name
Trimethylmethanol	Standard	45	48	<i>Tert.</i> butyl
2-Methylpropanol-2	Standard	90	43	1,1-Dimethylpropyl
Dimethyl-ethyl-methanol	Standard	160	30	1-Methyl-1-ethyl-propyl
2-Methylbutanol-2	Standard	120	22	1,1-Diethylpropyl
Methyl-diethyl-methanol	Standard	150	11	1-Methyl-1-ethyl-butyl
3-Methylpentanol-3	Standard	240	16	
Triethylmethanol	Standard	180	19 ¹	1,1-Dimethylpentyl
3-Ethylpentanol-3	20 ml ethanol	300	20 ²	1,1,2,2-tetramethyl-propyl
Methyl-ethyl-propyl-methanol	20 ml ethanol	300	15 ³	1-Methyl-1-isopropyl-propyl
3-Methylhexanol-3	20 ml ethanol	240	5 ⁴	
Dimethyl-butyl-methanol	10 ml ethanol			1-Methyl-1-phenyl-propyl
2-Methylhexanol-2	No reaction neither as chloride nor as bromide			1-Methyl-1-benzyl-propyl
Dimethyl- <i>tert.</i> butyl-methanol	No reaction			
2,3,3-Trimethylbutanol-2	No reaction			1,1-Diphenylpropyl
Methyl-ethyl- <i>isopropyl</i> -methanol	No reaction			Triphenylmethyl
2,3-Dimethylpentanol-3	No reaction			
Methyl-ethyl-phenyl-methanol	No reaction			
2-Phenylbutanol-2	No reaction			
Methyl-ethyl-benzyl-methanol	No reaction			
1-Phenyl-2-methyl-butanol-2	No reaction			
Ethyl-diphenyl-methanol	No reaction			
1,1-Diphenylpropanol-1	No reaction			
Triphenylmethanol	No reaction			

¹ Contaminated with traces of S-ethylthiuronium picrate

² The alcohol shaken with constant boiling hydrobromic acid instead of concentrated hydrochloric acid

³ Contaminated with considerable amounts of S-ethylthiuronium picrate

⁴ Not contaminated with S-ethylthiuronium picrate

This procedure had to be abandoned, as the S-alkylthiuronium picrates isolated were strongly contaminated with picric acid.

As alkyl iodides react more rapidly than alkyl chlorides it was tried to add potassium iodide to the reaction mixture. This procedure, too, was abandoned as the precipitate obtained consisted mainly of potassium picrate. Sodium iodide is presumably preferable to potassium iodide, sodium picrate being much more soluble in ethanol and water than potassium picrate.

In Table 2 melting points of and nitrogen-determination in picrates not previously described are reported. All melting points are determined by plunging capillary tubes into a bath previously heated to some degrees under the m.p. All m.p.'s are corrected.

The above mentioned assumption about the reaction between a tertiary alkyl halide and the solvent, ethanol, seems to be corroborated by the appearance of S-ethylthiuronium picrate as a contamination of the S-tertiary alkylthiuronium picrate, when 80 % ethanol was used as a solvent instead of 35 % ethanol. The formation of the ethyl derivative is of course most probable in the more concentrated ethanol solution, but it is also noteworthy that a decrease in dielectric constant will considerably retard the rate of the reaction between the tertiary alkyl ion and thiourea (S_1 -reaction) but somewhat accelerate the S_2 -reaction between ethyl chloride, rapidly formed from the halide and the solvent, and thiourea. S-Ethylthiuronium picrate is thus obtained as a by-product in the case with lower dielectric constant, *i. e.* with 80 % ethanol as a solvent (Table 1).

Table 2. Melting points of and nitrogen determination in some S-tertiary alkylthiuronium picrates.

Radical name	M.p.	% N	
		found	calculated
1-Methyl-1-ethyl-propyl	127°	18.17	17.98
1,1-Diethyl-propyl	113°	17.50	17.37
1-Methyl-1-ethyl-butyl	124°	17.38	17.37
1,1-Dimethyl-pentyl	108°	17.18	17.37
1,1,2,2-Tetramethyl-propyl	125°	17.39	17.37
1-Methyl-1- <i>isopropyl</i> -propyl	122°	17.18	17.37

For the formation of S-*primary* alkylthiuronium picrates a S_2 -reaction, *i. e.* a second order substitution reaction, was assumed responsible. Its velocity is no doubt dependent on the proportion of thiourea present in the *iso*-form and this, on the other hand, is dependent on the solvent used, solvents with a high dielectric constant favouring the *iso*-form. A corroboration of this assumption was obtained by comparing the yield obtained when *n*-butyl chloride was refluxed with thiourea, one time using the standard procedure and the other time using 80 % ethanol as a solvent (Table 3).

Table 3. Comparison of the yield of the reaction between *n*-butyl chloride and thiourea in 35 % ethanol and in 80 % ethanol.

Time of refluxing in minutes		Yield in %	
35 % ethanol	80 % ethanol	35 % ethanol	80 % ethanol
	30		3
	60		7
	120		12
150	180	15	18
210	360	30	29 ¹

¹ Contaminated with S-ethylthiuronium picrate.

It is seen that the velocity is somewhat greater in 35 % ethanol than in 80 % ethanol and besides, that here, too, the conversion of the alkyl chloride used into ethyl chloride may be observed in 80 % ethanol when the mixture is refluxed for a very long time.

The fact that the 4 last mentioned tertiary alcohols in Table 1 do not react with thiourea may be due to the failure of converting the alcohols into halides by shaking them with concentrated hydrobromic or hydrochloric acid. The reason may also be that the tertiary halides in question do not react with thiourea. For triphenylmethanol we tried to use preformed pure triphenylmethyl chloride instead of with hydrochloric acid treated alcohol, but no S-alkylthiuronium picrate was obtained, even so.

It is, however, well known that triphenylmethyl chloride will react easily with alcohols, forming triphenylmethyl ethers. This can possibly explain the failing reaction with thiourea. But the problem can also be discussed from another point of view and an explanation of the result given by comparison with the behaviour of triphenylmethane thiol. This thiol, which contains a C—S-linkage of the same kind as the one in the thiourea derivative wanted, splits easily away the mercapto group, forming triphenylcarbenium ions. In water solution thus triphenylmethanol and hydrogen sulphide are formed. The conclusion is of course that aryl groups strongly weaken the C—S-linkage so that, applied to the reaction between triphenylmethyl chloride and thiourea, even if a formation of the arylsubstituted alkylthiuronium halide takes place by a S₁-mechanism, such a substance may by prolonged heating be converted into the corresponding alcohol or its ethyl ether. Thus the thiourea derivative cannot be isolated.

In the above mentioned paper¹ one of us drew attention to the variation of the melting points of the S-alkylthiuronium picrates and styphnates with the number of carbon atoms. We have now supplemented this material with the picrates described in this paper, and from Table 4 can be seen that also the newly prepared picrates fit well into the regularity found previously but, besides, that the melting points are dependent on the symmetry of the carbon chain.

The S-alkylthiuronium picrates are not only well fitted as derivatives for characterisation of tertiary alcohols, they are, too, useful for the estimation of these alcohols, which till now have been difficult to estimate, due to the difficulty with which they are acetylated or converted into derivatives containing easily estimatable groups.

It is well known that salts of not too strong acids behave as bases when they are dissolved in glacial acetic acid and titrated with a standard solution of perchloric acid in glacial acetic acid (see *e. g.* Markunas and Riddick⁴). Berger⁵ has recently shown that S-benzylthiuronium salts of carboxylic acids may be estimated in this way. The S-alkylthiuronium picrates, too, can be titrated with perchloric acid. The titration can be carried out electrometrically or with crystal violet as an indicator. The picrate ion may also be used as an indicator, the alkylthiuronium picrates dissolving in glacial acetic

Table 5. Equivalent weights of some S-alkylthiuronium picrates.

Alcohol	E_{salt}		E_{alcohol}	
	found	calc.	found	calc.
<i>n</i> -Butanol	359.4	361.3	72.2	74.1
Trimethylmethanol	359.9	361.3	72.7	74.1
Dimethyl-ethyl-methanol	374.6	375.4	87.4	88.2
Methyl-diethyl-methanol	387.9	389.4	100.7	102.2
Triethylmethanol	402.4	403.4	115.2	116.2
Methyl-ethyl-propyl-methanol	401.4	403.4	114.2	116.2
Dimethyl-butyl-methanol	402.7	403.4	115.5	116.2
Dimethyl- <i>tert.</i> butyl-methanol	401.7	403.4	114.5	116.2
Methyl-ethyl- <i>isopropyl</i> -methanol	405.2	403.4	118.0	116.2

acid with an intense yellow colour which during the titration fades, and when the equivalent amount of perchloric acid has been added a colourless solution results; picric acid dissolving in glacial acetic acid without colour. Table 5 shows some results found for the equivalent weight of some S-alkylthiuronium picrates. From these values the equivalent weight of the alcohols may be found by subtracting 287.2.

It is seen that the number of carbon atoms in the alcohol is determined with sufficient exactitude.

For preparative purposes, too, the S-*tertiary* alkylthiuronium derivatives are useful. It is well known that a convenient method for preparing thiols consists in preparing S-alkylthiuronium salts and treating these compounds with sodium hydroxide. Through the S-*tertiary* alkylthiuronium salts, now investigated, tertiary alkane thiols thus become readily available.

SUMMARY

S-*tert.* Alkylthiuronium picrates have been investigated and a method for their preparation is indicated.

The mechanism of the reaction is discussed in order to find an explanation of the fact that the preparation of S-*tert.* alkylthiuronium salts is possible when aqueous ethanol is used as a solvent, but not when the solvent is absolute ethanol.

A method for the estimation of tertiary alcohols by use of S-*tert.* alkylthiuronium picrates is described.

Attention is drawn to the possibility of preparing tertiary alkane thiols from the S-*tert.* alkylthiuronium salts.

REFERENCES

1. Schotte, L. *Arkiv Kemi* **5** (1952) No. 2.
2. Wild, F. *Characterisation of Organic Compounds*, Cambridge, University Press, 1947, p. 42 and 48.
3. Veibel, S., and Lillelund, H. *Bull. Soc. Chim. France* **5:5** (1938) 1153.
4. Markunas, P. C., and Riddick, J. A. *Anal. Chem.* **23** (1951) 337.
5. Berger, J. *Beretning fra 8. Nord. Kemikermøde*, Oslo 1953.

Received September 18, 1953.