Acta Chemica Scandinavica B 29 (1975) 141—144

Reactions between Azolium Anions and Electrophilic Reagents. I. Direct Thiation of 1,3-Disubstituted 1,2,3-Triazolium Anions with Sulfur

MIKAEL BEGTRUP

Department of Organic Chemistry, Technical University of Denmark, DK-2800 Lyngby, Denmark

Direct thiation of 1,3-disubstituted 1,2,3-triazolium tosylates *1* with elemental sulfur and sodium hydride in dimethylformamide proceeds selectively to give 1,3-disubstituted 4-(1,2,3-triazolio)sulfides *2* in high yields.

4-(1,2,3-Triazolio)sulfides *2* have been obtained previously by treatment of halogen-substituted 1,2,3-triazolium salts *3* with sulfide ions.[1]

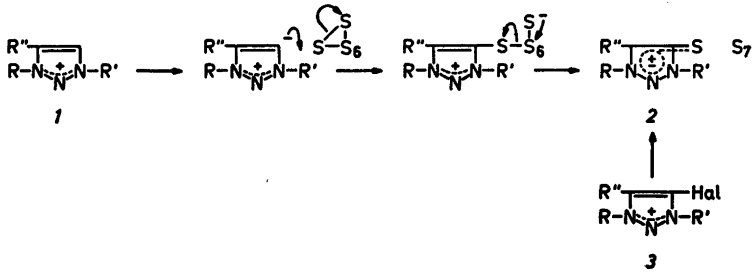
Recently, imidazolium-,[2] thiazolium-,[3] and 1,2,4-triazolium [4,5] salts have been thiated with elemental sulfur *via* their anions using pyridine or triethylamine as proton abstractors. A similar thiation of 1,3-disubstituted 1,2,3-triazolium salts *1* to give 1,3-disubstituted 4-(1,2,3-triazolo)sulfides *2** would be attractive since simple 1,2,3-triazolium salts *1* are more readily accessible than their halogen substituted derivatives *3*.

* The reaction is formulated as an ionic process analogous to the thiation of other carbanions.[6–9]

However, thiation of 1,2,3-triazolium salts *1* by treatment with sulfur, pyridine, and triethylamine proved to be inconvenient since separation of the products from the triethyl ammonium salts formed was tedious and caused loss in yield. Thiation of *1* with sulfur using other bases and media was therefore attempted. Among several systems sodium hydride in dimethylformamide was found to be the best, resulting in a simpler isolation procedure and in high yields of thiation products (Table 1). This modified thiation method is superior to the substitution process (*3*→*2*). In addition, the direct thiation method makes new types of 4-(1,2,3-triazolio)sulfides available.

Until now, halogen substituted 4-(1,2,3-triazolio)sulfides *2* (R″=Hal) have been inaccessible since treatment of dihalogen substituted 1,2,3-triazolium salts *3* (R″=Hal) with sulfide ions leads to decomposition.* The alternative halo-

* Begtrup, M. Unpublished results.



Scheme 1.

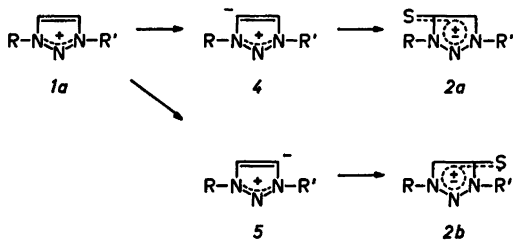
Table 1. Conversion of 1,3-disubstituted 1,2,3-triazolium tosylates into 1,3-disubstituted 4-(1,2,3-triazolio) sulfides.

Starting material *1* (or *1a*)			Ref.	Product(s) *2* (or *2a* or *2b*)			Crude product Yield %	Crude product M.p. °C	M.p. of pure compound °C	Reported m.p. °C	Analytical data Found / Calc. C %	H %	N %	S %	Hal %
R	R′	R″		R	R′	R″									
CH_3	CH_3	H	13	CH_3	CH_3	H	100	170–171	171–172[b]	172–173[1]					
$CH_2C_6H_5$	$CH_2C_6H_5$	H	10	$CH_2C_6H_5$	$CH_2C_6H_5$	H	97	95–96	122–123[c]		66.60	5.26	14.56	10.90	
											68.32	5.37	14.94	11.39	
CH_3	CH_3	Br	13	CH_3	CH_3	Br	56	158–160	162–163[b]		23.17	2.95	20.01	15.47	Br: 38.47
											23.09	2.91	20.19	15.41	38.40
$CH_2C_6H_5$	CH_3	Cl	14	$CH_2C_6H_5$	CH_3	Cl	71	134–139	141–144[b]		50.09	4.11	17.36		Cl: 14.70
											50.10	4.21	17.53		14.79
CH_3	$CH_2C_6H_5$	Cl	14	CH_3	$CH_2C_6H_5$	Cl	38	131–134	131–134[d]		49.95	4.20	17.46	13.39	Cl: 14.98
											50.10	4.21	17.53	13.38	14.79
CH_3	C_6H_5	CH_3	10	CH_3	C_6H_5	CH_3	87	148–149	148–149[d]		58.40	5.47	20.50	15.58	
											58.50	5.40	20.47	15.62	
$CH_2C_6H_5$	CH_3	H	10	$CH_2C_6H_5$	CH_3	H	32[a]	119–123	130[b]	127–129[1]					
				CH_3	$CH_2C_6H_5$	H	47[a]	132–133	132–134[d]	137–139[1]					
C_6H_5	CH_3	H	10	C_6H_5	CH_3	H	10[a]	188–191	202–204[b]	193–194[15]					
				CH_3	C_6H_5	H	73[a]	98–100	107–108[b]	112[1]					

[a] Yields isolated by column chromatography. The composition of the initial product mixture is given in Experimental. [b] Recrystallized from ethyl acetate. [c] Recrystallized from chloroform-ether. [d] Recrystallized from ethyl acetate-hexane.

genation of 4-(1,2,3-triazolio)sulfides leads to attack on the sulfur atom with formation of sulfenyl halides.[1] However, direct thiation of monochloro- or monobromo 1,2,3-triazolium salts *1* (R″=Hal) affords halogen substituted 4-(1,2,3-triazolio)sulfides *2* (R″=Hal) in good yields (Table 1).

Direct thiation of 1,2,3-triazolium salts *1a* with two different *N*-substituents gives rise to a mixture of two isomeric 4-(1,2,3-triazolio)-sulfides *2a* and *2b*.



Scheme 2.

A separate experiment indicated that *2a* (R=CH_3, R′=$CH_2C_6H_5$) does not isomerize to *2b* (R=CH_3, R′=$CH_2C_6H_5$) under the reaction conditions.

Provided that the deprotonation of *1a* is the rate limiting step, the ratio between *2a* and *2b* is determined by the relative stability of the anions *4* and *5*. This, in turn, is reflected by the ratio between the rates of base catalyzed deuterium exchange of the ring protons in the starting material *1a*. In *1a* (R=$CH_2C_6H_5$, R′=CH_3), H-4 is exchanged 1.2 times faster than H-5.[10] Thus, thiation of *1a* (R=$CH_2C_6H_5$, R′=CH_3) is expected to produce *2a* and *2b* (R=$CH_2C_6H_5$, R′=CH_3) in this ratio. The ratio found is 1.4. This agreement would be in accordance with the suggested mechanism assuming kinetic control. On the other hand, H-4 is exchanged 2.4 times faster than H-5 in *1a* (R=C_6H_5, R′=CH_3) [10] whereas thiation of *1a* (R=C_6H_5, R′=CH_3) yields *2a* and *2b* (R=C_6H_5, R′=CH_3) in the ratio 9.3. This discrepancy is incompatible with deprotonation as the rate limiting step. Hence precautions are advisable in predicting the distribution of thiation products, based on deuterium exchange measurements on the starting material.

EXPERIMENTAL

Column chromatography was carried out as described previously.[11] Melting points are uncorrected. NMR spectra were obtained on a Varian A-60 instrument. IR spectra were measured in potassium bromide pellets. The purity of all compounds were checked by TLC.

General procedure for the preparation of 1,3-disubstituted 4-(1,2,3-triazolio) sulfides *2*.

Equimolar amounts of 1,3-disubstituted 1,2,3-triazolium tosylate *1* and sulfur (S_8) were dried carefully over phosphorus pentaoxide at 0.1 mmHg. A 55 % suspension of sodium hydride in mineral oil (Fluka) was then added using 1.1 equiv. when the starting material was halogen substituted and 3 equiv. in all other cases.*

The air in the reaction flask was replaced with dry nitrogen and the mixture was cooled to −70 °C.

Dry dimethylformamide [12] (20 ml per g of sodium hydride suspension) was then added with magnetic stirring. Stirring was continued at −70 °C for ½ h. The cooling bath was then removed and the mixture was stirred overnight at room temperature. Moisture was carefully excluded in all operations. The dimethylformamide was then removed *in vacuo*, the temperature in the flask being kept below 100 °C. The residue was extracted with methanol (4 × 20 ml per 0.01 mol of starting material) and the solution was neutralized with conc. acetic acid. The methanol was evaporated and the residue was extracted with boiling ethyl acetate (4 × 40 ml per 0.01 mol of starting material). The ethyl acetate was evaporated and the residue was extracted three times with hexane (20 ml per 0.01 mol of starting material) leaving the crude product.

When an NMR-spectrum of the crude product proved that only one isomer was present purification was effected by recrystallization as described in Table 1.

When the NMR spectrum indicated that the crude product contained two isomers separation was achieved by column chromatography as described below.

1-Methyl-3-benzyl-1,2,3-triazolium tosylate 1a (R=$CH_2C_6H_5$, R′=CH_3) gave a mixture of the 4-(1,2,3-triazolio)sulfides *2a* and *2b* (R=$CH_2C_6H_5$, R′=CH_3), in the ratio 1.44:1 according to the NMR spectrum. Column chromatography (30 g of silica gel per 100 mg of mixture) eluting with ethyl acetate first gave [1-benzyl-3-methyl-4-(1,2,3-triazolio)]sulfide *2b* (R=$CH_2C_6H_5$, R′=CH_3). The second fraction contained [1-methyl-3-benzyl-4-(1,2,3-triazol-

* Use of only 1.1 equiv. of sodium hydride in the latter cases reduced the yield with up to 10 %, absolute.

Table 2. NMR spectroscopic data (δ) of 1,3-disubstituted 4-(1,2,3-triazolio)sulfides.[a]

Compound *2*	H-5	N-CH_2	N-CH_3	C-CH_3
[1,3-Dibenzyl-4-(1,2,3-triazolio)]sulfide	[b]	8.72 9.05		
[1,3-Dimethyl-5-bromo-4-(1,2,3-triazolio)]-sulfide			4.10 4.12	
[1-Methyl-3-benzyl-5-chloro-4-(1,2,3-triazolio)]sulfide		5.76	4.07	
[1-Benzyl-3-methyl-5-chloro-4-(1,2,3-triazolio)]sulfide		5.58	4.08	
[1,5-Dimethyl-3-phenyl-4-(1,2,3-triazolio)]sulfide			3.98	2.37

[a] The spectra were recorded in deuteriochloroform solution. Position of signals are given in ppm relative to tetramethylsilane (TMS) (δ-values).
[b] The signal is hidden by the phenyl group absorption.

io)]sulfide *2a* (R=$CH_2C_6H_5$, R′=CH_3). The compounds were purified further by recrystallization. Yields and details are given in Table 1.

1-Methyl-3-phenyl-1,2,3-triazolium tosylate 1a (R=C_6H_5, R′=CH_3) produced *2a* and *2b* in the ratio 9.27:1 as shown by the NMR spectrum of the crude product. Column chromatography (7.5 g of silica gel per 100 mg of mixture, ethyl acetate) afforded [1-phenyl-3-methyl-4-(1,2,3-triazolio)]sulfide *2b* (R=C_6H_5, R′=CH_3). The column was then eluted with ethyl acetate-methanol (1:1) to give [1-methyl-3-phenyl-4-(1,2,3-triazolio)]sulfide *2a* (R=C_6H_5, R′=CH_3). Yields and recrystallization media are given in Table 1.

All previously described compounds were identified through their melting point, IR, and NMR spectra. The new compounds were identified through their analyses (Table 1) and their NMR spectra (Table 2).

The author is indebted to civilingeniør S. Refn for the infrared spectra. Microanalyses were performed by Dr. A. Bernhardt, Mikroanalytisches Laboratorium.

REFERENCES

1. Begtrup, M. *Acta Chem. Scand. 26* (1972) 1243.
2. Schönherr, H.-J. and Wanzlick, H.-W. *Justus Liebigs Ann. Chem. 731* (1970) 176.
3. Wanzlick, H.-W., Kleiner, H.-J., Lasch, I., Füldner, H. U. and Steinmaus, H. *Justus Liebigs Ann. Chem. 708* (1967) 155.
4. Walentowski, R. and Wanzlick, H.-W. *Z. Naturforsch. B 25* (1970) 1421.
5. Becker, H. G. O. Nagel, D. and Timpe, H.-J. *J. Prakt. Chem. 315* (1973) 97.
6. Pryor, W. A. *Mechanisms of Sulfur Reactions*, McGraw, New York 1962, p. 7.
7. Schumann, H. In Senning, A., Ed., *Sulfur in Organic and Inorganic Chemistry*, Dekker, New York 1972, Vol. 3, p. 1.
8. Foss, O. In Kharasch, N. and Meyers, C. Y., Eds., *The Chemistry of Organic Sulfur Compounds*, Pergamon, Oxford 1961, Vol. 1, p. 83.
9. Mayer, R. *Z. Chem. 13* (1973) 321.
10. Begtrup, M. *Acta Chem. Scand. 25* (1971) 249.
11. Begtrup, M. *Acta Chem. Scand. 27* (1973) 2051.
12. Bunnett, J. F. and Scorrano, G. *J. Amer. Chem. Soc. 93* (1971) 1190.
13. Begtrup, M. and Kristensen, P. A. *Acta Chem. Scand. 23* (1969) 2733.
14. Begtrup, M. *To be published.*
15. Begtrup, M. *Acta Chem. Scand. 25* (1971) 3500.

Received August 7, 1974.