Tetrahedron Letters No. 11, pp 901 - 904, 1974. Pergamon Press. Printed in Great Britain.

CONVERSION OF N,N'-DI-t-BUTYLSULFAMIDE TO METHYL t-BUTYLSULFAMATE

Boris Weinstein and Hsien-Hsin Chang

Department of Chemistry BG-10, University of Washington

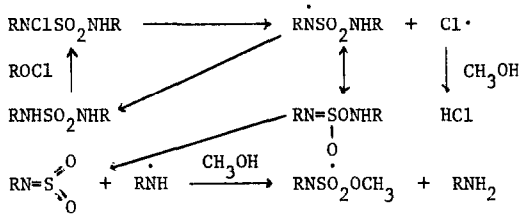
Seattle, Washington 98195, U.S.A.

(Received in USA 28 November 1973; received in UK for publication 1 February 1974)

N,N'-Disubstituted sulfamides are a reactive group of compounds and undergo nucleophilic attack at sulfur (1) or nitrogen (2,3), depending on the exact experimental conditions. We wish to report here a new reaction that has some interesting synthetic applications.

Treatment of N,N'-di-t-butylsulfamide with one equivalent of t-butyl hypochlorite in methanol for 30 minutes affords only N-chloro-N,N'-di-t-butylsulfamide (4). By contrast, when three equivalents of hypochlorite are used, and the reaction is allowed to proceed overnight, then the products are t-butylamine hydrochloride (19%) and methyl t-butylsulfamate (86%): mp 62-63°; ir (KBr) 3278 (NH), 1396, 1361 (t-Bu), 1330 (SO_2 asym.), 1150 (SO_2 sym.), 931, 880 (N-SO_2) cm^{-1}; nmr ($CDCl_3$) τ 8.63 (s,9), 6.19 (s,3), 5.33 (broad, 1); ms m^+/e 167. If N-chloro-N,N'-di-t-butylsulfamide stands in methanol for a similar period, then there is found a mixture (4:5) of both N,N'-di-t-butylsulfamide and methyl-t-butylsulfamate, but no t-butylamine hydrochloride. The addition of excess t-butyl hypochlorite to a methanol solution of N-chloro-N,N'-di-t-butylsulfamide under the same conditions generates t-butylamine hydrochloride (79%) and methyl t-butylsulfamate (98%).

Although the exact mechanism is not known at this time, the following scheme can be used to explain the results (R=t-Bu):

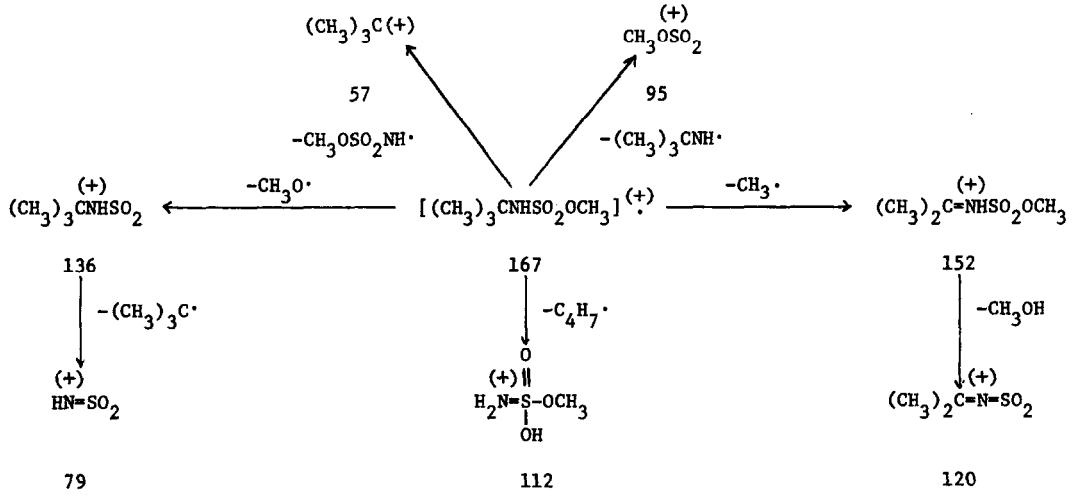


First, it is assumed that N-chloro-N,N'-di-t-butylsulfamide fragments into the radicals $RNSO_2NHR$ and Cl·. The former is resonance stabilized and can decompose by a cleavage of the central N-S bond to afford N-sulfonyl-t-butylamine and t-butylamine radical. Next, in the presence of methanol, these intermediates further react to give the observed sulfamate ester,

plus t-butylamine. Since chlorine radical can combine with solvent to afford hydrogen chloride, then the free amine is converted into the corresponding salt. The remaining observations are easily explained by permitting the sulfamide radical to react with methanol (5) to yield di-t-butylsulfamide. The latter, in the presence of excess t-butyl hypochlorite, is changed into the parent N-chlorosulfamide, and the reaction cycle commences again.

Attention is drawn to the point that the above postulated mechanism makes use of the elusive N-sulfonylamine system in the form of N-sulfonyl-t-butylamine, $RNSO_2$. Little information is available in the literature on this type of compound, but two other studies have been located that bear on this suggestion. Irradiation of benzenesulfonyl azide in methanol was reported to lead to methyl phenylsulfamate, presumably by way of N-sulfonylaniline, $C_6H_5NSO_2$ (6). This conversion is of special interest because the intermediate readily afforded a sulfamate ester, similar to our result. In a more recent investigation, both N-sulfonylethylamine and N-sulfonylbenzamide were generated in situ at low temperatures and were trapped in the form of adducts (7). Thus, there is some precedence for the proposed reaction sequence.

Additional support for the N-sulfonylamine intermediate is seen in the mass spectrum of methyl t-butylsulfamate, whose fragmentation pattern is as follows:



Note that these assignments provide good evidence for the structure assigned to the parent material.

An equally plausible ionic mechanism can be outlined as follows (8):

$$RNClSO_2NHR \xrightarrow{ROCl} RNCl_2SO_2NHR^{(+)} \xrightarrow{CH_3OH} RNHSO_2OCH_3 + RNCl_2$$

$$RNCl_2 + 2CH_3OH \rightleftharpoons RNH_2 + 2CH_3OCl$$

$$RNH_2 + H\text{-}CH_2\text{-}O\text{-}Cl \longrightarrow RNH_3Cl + CH_2O$$

In the case where the N-chloro compound was allowed to stand overnight, disproportionation could explain the results where there was obtained a nearly equal ratio of products.

$$2RNClSO_2NHR \longrightarrow RNCl_2SO_2NHR^{(+)} + RNSO_2NHR^{(-)}$$

$$RNCl_2 + RSO_2NHOCH_3 \quad (CH_3OH) \qquad RNHSO_2NHR \quad (CH_3OH)$$

Variations in the yield of t-butylamine hydrochloride may be explained by the relative efficiency of conversion of $RNCl_2$ under different conditions, such as when excess ROCl is present. Thus:

$$RNCl_2 \longrightarrow RNHCl + CH_3OCl$$

$$RNHCl \rightarrow RHN:\uparrow\uparrow^{(+)} \quad Cl^{(-)} \xrightarrow{CH_3OH} RNH_3Cl$$

Here, the $RNCl_2$ reacts with solvent to yield $RNHCl_2$, which decomposes to the singlet nitrenium ion, $RHN:\uparrow\downarrow^{(+)}$. This species can not abstract a hydrogen, so it undergoes a spin inversion to the unpaired ion. Such a postulated triplet nitrenium ion has been shown previously to afford a similar ammonium ion (9).

Only a few alkyl sulfamate esters are known at present and their synthesis involves completely different routes (10,11). By contrast, alkyl amines on treatment with sulfuryl chloride easily give dialkylsulfamides, which, in turn, can serve as precursors to a variety of sulfamates. This new route should be explored in greater detail in the near future, since related compounds are in use as sweeting agents (i.e., saccharin).

Acknowledgment: We thank Dr. Catherine Fenselau, Department of Pharmacology, Johns Hopkins University, for the mass spectrum and a discussion of the details.

REFERENCES

1. F. L. Scott, J. A. Barry, and W. J. Spillane, J. Chem. Soc., Perkin I, 2666 (1962).

2. R. Sowada, J. Prak. Chem., 20, 310 (1963); ibid, 23, 128 (1964); ibid, 25, 88 (1964); ibid, 26, 184 (1964); ibid, 33, 240 (1966); ibid, 33, 247 (1966); ibid, 311, 288 (1969).

3. R. Sowada, Z. Chem., 8, 25 (1968).

4. H.-H. Chang and B. Weinstein, J. Chem. Soc., Chem. Commun., 397 (1973).

5. D. Y. Myers, G. G. Stroebel, B. R. Ortiz de Montellano, and P. D. Gardner, J. Amer. Chem. Soc., 95, 5832 (1973).

6. W. Lwowski and E. Scheiffele, J. Amer. Chem. Soc., 87, 4359 (1965).

7. G. M. Atkins, Jr., and E. M. Burgess, J. Amer. Chem. Soc., 94, 6135 (1972).

8. The ionic mechanism was suggested by a referee.

9. P. G. Gassman, Accounts Chem. Res., 3, 26 (1970).

10. R. Sowada, J. Prak. Chem., 29, 328 (1965).

11. R. Appel and W. Senkpiel, Z. anorg. allgem. Chem., 310, 94 (1961).