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NEW SELECTIVE OXIDATION OF THIOLS TO THE CORRESPONDING THIOLSULFONATES WITH DINITROGEN TETROXIDE: ONE POT SYNTHESES OF THIOLSULFONATES FROM THIOLS

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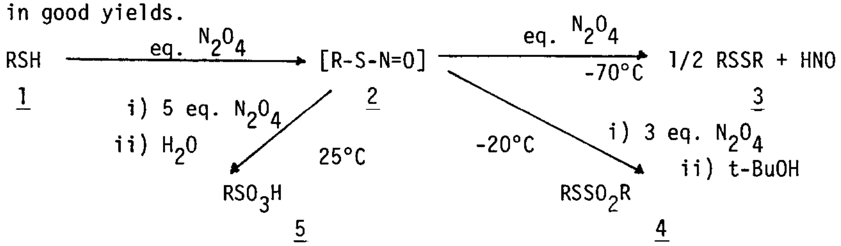
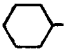
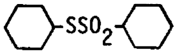
We have recently reported that the reactions of thiols with an equimolar amount of N_2O_4 readily afford the thionitrites quantitatively[1]. We have now found that the both aromatic and alkyl thiols reacted readily with excess N_2O_4 at low temperatures(ca. -20°C) to afford the corresponding thiolsulfonates in good yields.

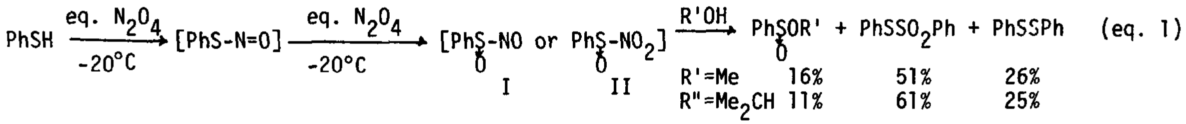


Symmetrical thiolsulfonates have been generally synthesized by the oxidation of disulfides or by the reaction of sulfinic acids with sulfenyl chlorides[2]. These methods, however, involve two o more reaction steps and form the side products such as thiolsulfonates or sulfonic acids. Our new method is simple and involves only one pot reaction: when thiols were mixed with excess N_2O_4 at ca. -20°C and then quenched with t-butanol, the corresponding thiolsulfonates(4) were obtained in good yields in such an inert solvent as ether, acetonitrile or chloroform. A solution of N_2O_4(20.0 mmol CCl_4: ca. -20°C) was added to a solution of a thiol(5.0 mmol) in anhydrous ether(15 ml) with stirring at ca. -20°C in the dark. Immediately, the mixture colored to bright red, characteristic of the thionitrite(2)[1], which solution was stirred further for 1-5 min until the red color disappeared The mixture was quenched with t-butanol(5 ml) and then washed with 5% aqueous sodium bicarbonate solution to remove unreacted N_2O_4 and the nitric acid formed during the reaction. The crude product from the organic layer was purified by a preparative tlc(silica-gel, 1 mm, solvent: ether/n-hexane=1/21). All these products were identified by comparing their ir, nmr, glc and llc with those of the authentic samples. The results are summarized in Table I. The yields of the thiolsulfonates are markedly high when the reaction temperatures are controlled at ca. -20°C and quenched with excess t-butanol. When the reaction mixture was quenched with methanol or isopropanol instead of t-butanol, methyl sulfinate or isopropyl sulfinate was obtained at the expense of the thiolsulfonate as shown in equation 1.

Table I. Reactions of Thiols with Dinitrogen Tetroxide

Run	Thiols	Reactn. Time(min)	Reactn. Temp.(°C)	N_2O_4/RSH	Products	Isolated Yields(%)
1	C_6H_5SH	5	-20	4	$C_6H_5SSO_2C_6H_5$	88
2	p-CH_3-C_6H_4SH	5	-20	4	p-CH_3-$C_6H_4SSO_2C_6H_4$-CH_3-p	80
3	p-Cl-C_6H_4SH	5	-20	4	p-Cl-$C_6H_4SSO_2C_6H_4$-Cl-p	77
4	p-NO_2-C_6H_4SH	1	0	4	p-NO_2-$C_6H_4SSO_2C_6H_4$-NO_2-p	70
5	-SH	5	-20	4		62
6	n-$C_8H_{17}SH$	1	0	4	n-$C_8H_{17}SSO_2C_8H_{17}$-n	60
7	t-BuSH	2-5	25	4	t-BuS-NO_2[3]	98
8	C_6H_5SH	5	-70	2	$C_6H_5SSC_6H_5$	ca. 100
9	C_6H_5SH	120	25	6	$C_6H_5SO_3H$	ca. 100
10	p-CH_3-C_6H_4SH	120	25	6	p-CH_3-$C_6H_4SO_3H$	ca. 100

The thionitrite formed initially appears to be oxidized further with excess N_2O_4 to an unstable intermediate such as I or II and methanol or isopropanol probably attacks the sulfinyl sulfur atom to form the corresponding sulfinate. However, the bulky t-butanol may not attack the sulfinyl sulfur atom due to the steric hindrance. When the reaction mixture was quenched with t-butanol, t-butyl sulfinate could not be detected. Probably, homolytic scission of the unstable intermediate, I or II may form the sulfinyl radical which are converted to the corresponding α-disulfoxide[4]. The α-disulfoxide would then be converted to the corresponding thiolsulfonate[4].



$$\text{PhSH} \xrightarrow[-20^\circ C]{\text{eq. } N_2O_4} [\text{PhS-N=O}] \xrightarrow[-20^\circ C]{\text{eq. } N_2O_4} [\underset{\text{I}}{\text{Ph}\underset{O}{S}\text{-NO}} \text{ or } \underset{\text{II}}{\text{Ph}\underset{O}{S}\text{-NO}_2}] \xrightarrow{R'OH} \text{Ph}\underset{O}{S}\text{OR'} + \text{PhSSO}_2\text{Ph} + \text{PhSSPh} \qquad \text{(eq. 1)}$$

$$\begin{array}{llll} R'=Me & 16\% & 51\% & 26\% \\ R''=Me_2CH & 11\% & 61\% & 25\% \end{array}$$

It is noteworthy that the same treatment of a thiol with 2 eq. N_2O_4 at -70°C gave the disulfide quantitatively(Run 8), whereas the treatment of the thiol with 6 eq. N_2O_4 at 25°C gave the sulfonic acid quantitatively(Run 9,10). Meanwhile, the treatment of t-Bu-SH with 3 eq. N_2O_4 gave the t-$BuSNO_2$ in an excellent yield(Run 7)[3]. Therefore, the corresponding thiolsulfonate, disulfide or sulfonic acid can be prepared selectively by the simple and selective oxidation of the thiol with N_2O_4 when the reaction temperature, time and the concentration of N_2O_4 were carefully controlled.

References and Notes

1) S. Oae, D. Fukushima and Y.H. Kim, J.C.S., Chem. Commun., 407 (1977). 2) F. Kliveryai, Magyar Kemiai Folyrat, Ung, Z. Chem., 64, 121 (1958): W.E. Savige, J.A. Maclaren, " Oxidation of Disulfide" Vol. 2, N. Kharasch, C.Y. Meyers, Chapter 15, Pergamon Press (1966). 3) The t-$BuSNO_2$ was identified by its ir, nmr and elemental anlysis. 4) M. Chau and J.L. Kice, J. Am. Chem. Soc., 98. 7711 (1976): S. Oae, Y.H. Kim, T. Takata and D. Fukushima, Tetrahedron Letters, 1195 (1977).