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Synthesis of N-(1,3-Oxathiol-2-ylidene)ternary Iminium Salts[1]

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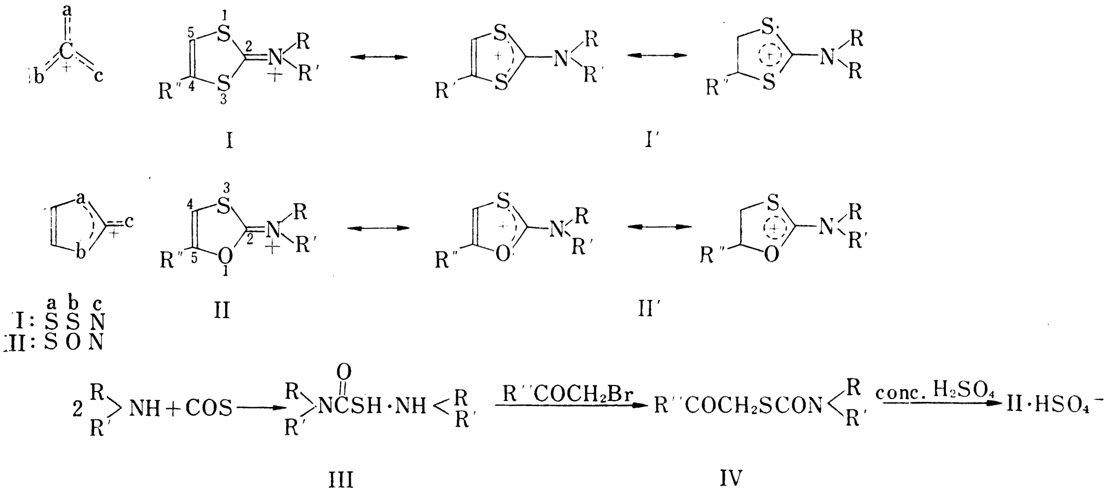
Novel S,O,N-triheterocation, N-(1,3-oxathiol-2-ylidene)ternary iminium ion (II), was synthesized by cyclization of phenacyl 1-piperidinecarbothiolate with concentrated sulfuric acid. A number of derivatives having various substituents at *para* position of 5-phenyl group in II were prepared. Physicochemical properties examined in these salts revealed that the immonium structure is more substantial than the 1,3-oxathiolium structure.

Carbonium ions containing three hetero atoms situated α to the ionic carbon atom have received some attention in recent years as stable trihetero substituted carbonium ions.[3] 2-Immonio-1,3-dithiole (I) and 2-immonio-1,3-oxathiole (II) are stabilized by the resonance forms 2-amino-1,3-dithiolium (I′) and 2-amino-1,3-oxathiolium (II′) ions, respectively; they are, therefore, interesting as 5-membered 6π-electrons ring systems. The ion I has already been synthesized[4] and its utility for the synthesis of 1,3-dithiolium ions has been demonstrated.[5] Our interest in sulfur-containing heterocyclic π-electron systems provided the impetus for an investigation of the ion II, which has not previously been synthesized.



$$2\,{}^{R}_{R'}\!\!>NH + COS \longrightarrow {}^{R}_{R'}\!\!>N\overset{O}{\overset{\|}{C}}SH\cdot NH<^{R}_{R'} \xrightarrow{R''COCH_2Br} R''COCH_2SCON<^{R}_{R'} \xrightarrow{conc.\ H_2SO_4} II\cdot HSO_4^-$$

Chart 1

For the synthesis of the novel S,O,N-triheterocation II, a method analogous to that used for the synthesis of the S,S,N-triheterocation I was applied. Piperidine was allowed to react with carbonyl sulfide giving piperidinium 1-piperidinecarbothiolate[6] III; reaction of

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1) This paper forms Part V of "Studies on Heterocyclic Cation Systems," Part IV of this series is "Studies on 1,3-Dithiolium Cation-IV," K. Hirai, *Tetrahedron*, **27**, 4003 (1971)

2) Location: *Sagisu, Fukushima-ku, Osaka.*

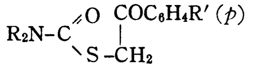
3) For review, see T. Nakai, *Yuki Gōsei Kagaku Kyōkai Shi*, **28**, 708 (1970).

4) E. Campaign and N.W. Jacobsen, *J. Org. Chem.*, **29**, 1703 (1964).

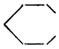
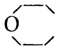
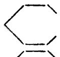
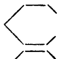
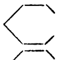
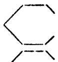
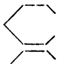
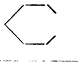
5) A. Takamizawa and K. Hirai, *Chem. Pharm. Bull.* (Tokyo), **17**, 1924 (1969).

6) J. Parrod, *Compt. Rend.*, **234**, 1062 (1952).

Table I. β-Keto Thiocarbamate (IV)



$R_2N-C(=O)-S-CH_2-COC_6H_4R'(p)$

Compd. No.	R_2	R′	Yield (%)	mp (°C)	Formula		Anal. (%) C	H	N	S	UV λ_{max}^{EtOH} mμ (log ε)
1		H	89	42—43	$C_{14}H_{17}O_2NS$	Calcd. Found	63.85 63.75	6.51 6.75	5.32 5.33	12.18 12.45	244.5, 280 (sh) (4.15, 3.32)
2		H	55	80—81	$C_{13}H_{15}O_3NS$	Calcd. Found	58.85 59.10	5.70 5.88	5.28 5.22	12.09 12.33	234.5, 250 (sh) (4.34, 4.24)
3	$(CH_3)_2$	H	45	85—87[a]	$C_{11}H_{13}O_2NS$	Calcd. Found	59.16 59.27	5.87 5.68	6.27 6.42	14.36 14.46	244, 280 (sh) (4.13, 3.29)
4		OH	75	158—160	$C_{14}H_{17}O_3NS$	Calcd. Found	60.19 60.33	6.13 6.02	5.01 5.25	11.48 11.38	220, 284 (4.32, 4.25)
5		CH_3O	46	121—123	$C_{15}H_{19}O_3NS$	Calcd. Found	61.40 61.27	6.53 6.49	4.77 4.80	10.93 11.15	218, 284.5 (4.24, 4.24)
6		CH_3	67	83—85	$C_{15}H_{19}O_2NS$	Calcd. Found	64.95 65.20	6.90 6.94	5.05 5.12	11.56 11.83	256 (4.23)
7		Cl	64	81—82	$C_{14}H_{16}O_2NSCl$	Calcd. Found	56.46 56.64	5.41 5.43	4.70 4.73	10.77 10.70	255 (4.29)
8		Br	50	77—79	$C_{14}H_{16}O_2NSBr$	Calcd. Found	49.12 49.26	4.71 4.75	4.09 4.11	9.37 9.72	258.5 (4.30)
9		NO_2	60	147—149	$C_{14}H_{16}O_4N_2S$	Calcd. Found	54.53 54.53	5.23 5.23	9.09 9.10	10.40 10.62	264.5 (4.18)

a) 98—99°, S. Yoshida, *Chem. Pharm. Bull.* (Tokyo), **2**, 249 (1954).

phenacyl bromide with III afforded the phenacyl ester IV (Table I), which was easily cyclized with concentrated sulfuric acid to give N-(4-phenyl-1,3-oxathiol-2-ylidene)piperidinium ion (II-1) as the hydrosulfate, mp 193—194°, each step proceeding in good yield. The ultraviolet (UV) spectrum of the cyclized product in H_2O showed a maximum at 278 mμ (log ε 4.30), and this salt showed the strong infrared (IR) absorption band indicative of $>C=\overset{+}{N}<$, it may indicate that an immonium structure very likely predominates.[7] This was also manifested in the nuclear magnetic resonance (NMR) spectral data. The NMR spectrum in deuterium oxide showd broad signals ascribable to the piperidine ring at τ 8.13 (6H), 6.27 (2H), and 5.98 (2H). A multiplet (5H) due to the phenyl protons appeared at τ 2.12—2.58 and a singlet (1H) ascribable to the C-4 proton in the 1,3-oxathiole ring appeared at τ 2.63. The ion II

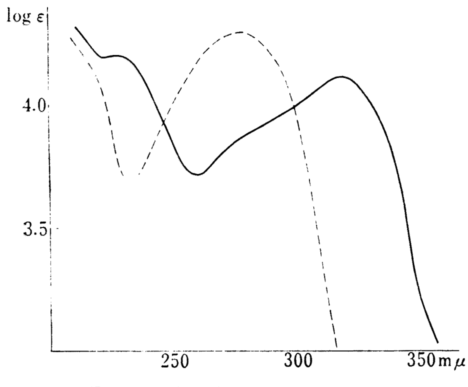


Fig. 1. UV Spectra in H_2O

——: I·HSO_4^- ------: II·HSO_4^-

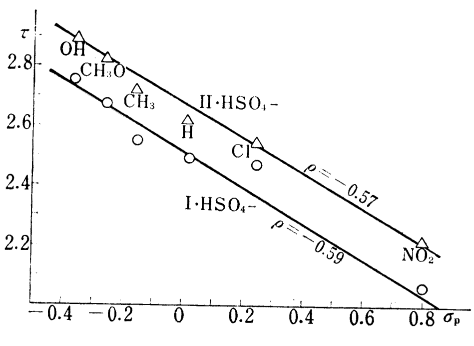


Fig. 2. NMR Chemical Shift (H-Ċ=) *vs* Hammett σ_p (D_2O)

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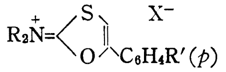
7) N.J. Leonard and J.V. Paukstelis, *J. Org. Chem.*, **28**, 3021 (1963).

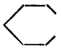
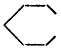
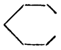
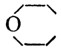
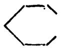
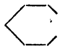
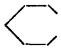
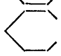
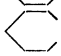
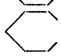
is an O-analogue of I and the NMR spectrum of II showed a pattern similar to that of I, though the chemical shift of the C-4 proton in the 1,3-oxathiole (II) was at a higher field than that of the corresponding C-5 proton in I (τ 2.50 in D_2O). The UV spectrum of I exhibited a bathochromic shift against II as shown in Fig. 1.

The hydrosulfate was easily converted into perchlorate or fluoroborate by treatment with perchloric acid or fluoroboric acid, respectively.

Use of morpholine or dimethylamine in the synthesis of II gave N-(1,3-oxathiol-2-ylidene)-morpholinium salt (II-4) or N-(1,3-oxathiol-2-ylidene)dimethylammonium salt (II-5), respectively. When various *p*-substituted phenacyl bromides were used in the synthesis of II, the corresponding N-(4-*p*-substituted phenyl-1,3-oxathiol-2-ylidene)piperidinium salts were obtained. The physicochemical data are summarized in Tables II and III.

Table II. 2-Immonio-1,3-oxathiole Derivatives (II)

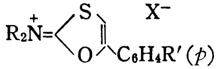


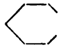
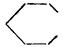
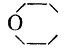
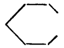
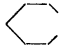
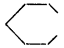
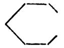
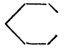
Compd. No.	R_2	R′	X	Yield (%)	mp (°C) (decomp.)	Formula		Anal. (%) C	H	N	S
1		H	HSO_4	83	193—194	$C_{14}H_{17}O_5NS_2$	Calcd. Found	48.96 49.20	4.99 5.06	4.08 4.07	18.68 18.88
2		H	ClO_4	100	175—177	$C_{14}H_{16}O_5NSCl$	Calcd. Found	48.63 48.79	4.66 4.77	4.05 4.00	9.27 9.31
3		H	BF_4	78.5	140—142	$C_{14}H_{16}ONSBF_4$	Calcd. Found	50.47 50.33	4.84 5.31	4.21 4.00	9.63 10.09
4		H	HSO_4	88	208—211	$C_{13}H_{15}O_6NS_2$	Calcd. Found	45.21 44.82	4.38 4.45	4.09 3.98	18.57 18.59
5	$(CH_3)_2$	H	HSO_4	93	217—218	$C_{11}H_{13}O_5NS_2$	Calcd. Found	43.55 43.37	4.32 4.22	4.62 4.70	21.15 21.21
6		OH	HSO_4	94	161—163	$C_{14}H_{17}O_6NS_2$	Calcd. Found	46.79 46.65	4.77 4.91	3.90 3.87	17.84 17.58
7		CH_3O	HSO_4	86	160—168	$C_{15}H_{19}O_6NS_2 \cdot H_2O$	Calcd. Found	46.02 46.30	5.41 5.50	3.58 3.42	16.38 16.78
8		CH_3	HSO_4	97	195—197	$C_{15}H_{19}O_5NS_2$	Calcd. Found	50.41 50.62	5.36 5.28	3.92 4.05	17.94 18.02
9		Cl	HSO_4	61	200—202	$C_{14}H_{16}O_5NS_2Cl$	Calcd. Found	44.50 44.42	4.27 4.41	3.71 3.74	16.98 16.94
10		Br	HSO_4	69	201—203	$C_{14}H_{16}O_5NS_2Br$	Calcd. Found	39.81 39.59	3.82 3.89	3.32 3.26	15.19 14.94
11		NO_2	HSO_4	36	208—210	$C_{14}H_{16}O_7N_2S_2$	Calcd. Found	43.29 43.56	4.16 4.24	7.21 7.31	16.51 16.26

The UV spectra of these compounds showed maxima at about 280 mμ. It could also be seen that the chemical shift of the C-4 proton in the NMR spectra was shifted upfield by electron donating groups and downfield by electron withdrawing groups. When the chemical shifts of the C-4 protons were plotted against Hammett's σ_p constants, a straight line was obtained giving ρ value of -0.57. The chemical shifts of the C-5 protons in N-(4-*p*-substituted phenyl-1,3-dithiol-2-ylidene)piperidinium fluoroborates have been examined in trifluoroacetic acid and found to have a linear correlation with Hammett's σ_p constants.[5] For comparison with the ion II, the NMR spectra of the hydrosulfate of I having the corresponding *p*-substituents in the C-4 phenyl group were examined in D_2O solution. The chemical shifts of the protons in the 5-membered ring were found to shift downfield on the replacement of oxygen by sulfur. The Hammett plots of the chemical shifts of the C-5 protons of I gave a straight line having a ρ value of -0.59 as shown in Fig. 2.

These results suggest that the charge densities at the C-5 position of I are lower than those at the C-4 position of II, though the shielding effects respond in a parallel way to changes

Table III. Spectra of 2-Immonio-1,3-oxathiole Derivatives (II)



Compd. No.	R_2	R′	X	UV λ_{max}^{EtOH} mμ (log ε)	IR $\nu_{C=N^+}^{KBr}$ (cm^{-1})	NMR,[a] τ (number of protons) R_2	S–CH=	C_6H_4R' (*p*)
1		H	HSO_4	213 (sh), 220 (sh), 278[b] (4.23, 4.12, 4.30)	1658, 1652	8.13^b (6), 6.27^b (2), 5.98^b (2)	2.63 (1)	2.12—2.58^m (5)
2		H	ClO_4	212.5, 220 (sh), 278 (4.31, 4.23, 4.29)	1651	8.23^b (6), 6.32^b (2) 5.95^b (2)	2.25 (1)	2.00—2.75^m (5)[c]
3		H	BF_4	213 (sh), 219 (sh), 277.5[b] (4.26, 4.13, 4.31)	1652			
4		H	HSO_4	213 (sh), 220 (sh), 276 (4.24, 4.20, 4.24)	1648, 1640	5.70—6.30^m (8)	2.57 (1)	2.17—2.58^m (5)
5	$(CH_3)_2$	H	HSO_4	211 (sh), 218 (sh), 274.5[b] (4.23, 4.09, 4.26)	1675	6.58 (3), 6.53 (3)	2.67 (1)	2.42 (5)
6		OH	HSO_4	216, 283 (4.33, 4.34)	1657	8.15^b (6), 6.00^b (2) 6.27^b (2)	2.90 (1)	A_2B_2: 2.48 (2), 3.05 (2)
7		CH_3O	HSO_4	217, 224 (sh), 283, 295 (sh) (4.26, 4.19, 4.35, 4.31)	1653	8.15^b (6), 6.23^b (2) 5.97^b (2)	2.85 (1)	A_2B_2: 2.35 (2), 2.91 (2); 6.10 (3)[d]
8		CH_3	HSO_4	216, 223, 280 (4.29, 4.18, 4.33)	1658	8.15^b (6), 5.98^b (2) 6.28^b (2)	2.76 (1)	A_2B_2: 2.40 (2), 2.53 (2); 7.58 (3)[d]
9		Cl	HSO_4	216.5, 223.5, 282.5 (4.29, 4.18, 4.34)	1652	8.08^b (6), 6.18^b (2) 5.90^b (2)	2.57 (1)	A_2B_2: 2.35 (2), 2.53 (2)
10		Br	HSO_4	217, 223.5, 283.5 (4.26, 4.20, 4.38)	1652	8.08^b (6), 6.17^b (2) 5.92^b (2)	2.57 (1)	A_2B_2: 2.32 (2), 2.50 (2)
11		NO_2	HSO_4	232, 325 (4.13, 4.13)	1660	8.10^b (6), 6.18^b (2) 5.83^b (2)	2.25 (1)	A_2B_2: 1.62 (2), 2.05 (2)

a) All NMR measurements were made in D_2O, by Varian A-60 Spectrometer and DSS was used as an internal reference. b: broad, m: multiplet
b) Spectra measured in H_2O.
c) Spectra measured in d_6-DMSO.
d) Singnal due to *para* substituents.

in the polarity of the substituents in both ions. Although the contribution from the polar structure to the resonance hybrids does not seem to be so large judging from the NMR spectra, the positive charge delocalization in I would be more substantial than in II.[8]

The results of the reactions of this novel trihetero cation II with nucleophiles will be reported in the near future.

Experimental[9]

General Procedure for the Preparation of β-Keto Thiocarbamates (IV)——A mixture of monothiocarbamates of secondary amines (1.1 mole) and phenacyl bromide derivatives (1 mole) in 200 ml of EtOH was refluxed for 2 hr. The reaction mixture was concentrated *in vacuo* and the residue was added H_2O, extracted with ether. The ether extract was dried over $MgSO_4$, evaporated *in vacuo* to give the residual crystals. Crude thiolcarbamate derivatives were recrystallized from the organic solvents to give thecolorless crystals (Table I).

General Procedure for the Preparation of N-(1,3-Oxathiol-2-ylidene)ternary Iminium Salts (II)——One gram of IV was added 1 g of conc. H_2SO_4 to give a clear solution with a slight evolution of heat. Ethyl acetate was added to the reaction mixture, and the separated oil was treated with EtOH to separate the crystals. The crystals were washed with EtOH–AcOEt to give the colorless crystals (Table II, III).

To the suspension of hydrosulfate in EtOH 70% $HClO_4$ or 42% HBF_4 was added to separate perchlorate or fluoroborate, respectively (Table II, III).

Added in Proof (Feb. 8, 1972) 2-Dialkylamino-1,3-oxathiolium salts have been independently prepared by the alternative method (H. Hartmann, *Z. Chem.*, **11**, 381 (1971)).

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8) W.G. Salmond, *Quart. Rev.*, **22**, 253 (1968).

9) Melting points are uncorrected.