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## Spectrometric Studies of 1, 3, 4-Thiadiazolo- [3,2-*a*] pyrimidines

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Spectrometric studies were carried out in order to distinguish between 5*H*-1,3,4-thiadiazolo [3,2-*u*] pyrimidin-5-ones and 7*H*-1,3,4-thiadiazolo [3,2-*a*] pyrimidin-7-ones. I.r. and u.v. suggested that the carbonyl group of 7-oxo isomer more polarized and  $\pi$ -electrons of the ring system more localized than those of the corresponding 5-oxo isomer. N.m.r. spectra were consistent with the fact. Mass spectra were also available to distinguish the isomers.

The authors found that 2-amino-1,3,4-thiadiazoles condensed with ethyl acetate in the presence of polyphosphoric acid preferably to yield 7-methyl-5*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-5-ones, but not the alternative compounds, 5-methyl-7*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-7-ones; the latter were prepared by cyclizing 2-acetoacetylaminothiadiazoles (Okabe *et al.*, 1973a, b).

Biological properties, such as fungicidal, larvicidal and herbicidal activity, were quite different between the 7-oxo and 5-oxo isomers (Okabe *et al.*, 1975). But as to chemical properties were not found such remarkable differences between them (Okabe *et al.*, 1974).

The present paper deals with comparison and interpretation of the spectra of 1,3,4-thiadiazolo[3,2-*a*]pyrimidones. A part of results for u.v. and i.r. had been published (Okabe *et al.*, 1973 a, b).

### EXPERIMENTAL

The u.v. spectra were measured in water solution on a double beam spectrophotometer, Shimazu Model UV-200.

The i.r. spectra were recorded on an infrared spectrophotometer, Shimazu Model IG-27 G, by use of KBr disks.

The n.m.r. spectra were measured on a JNM-MH-100 n.m.r. spectrometer, Japan Electron Optics Lab., by using deuterodimethylsulfoxide as solvent and tetramethylsilane as internal standard.

The mass spectra were determined with a JMS-01SG mass spectrometer, Japan Electron Optics Lab., by use of a direct inlet (source temperature 100°C; beam energy of 75 eV).

## RESULTS AND DISCUSSION

## A) Ultraviolet absorption spectra

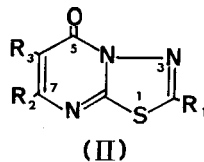
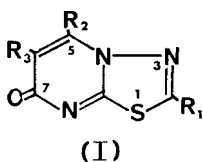
The u.v. absorption bands of some of 1,3,4-thiadiazolo[3,2-*a*] pyrimidones are enumerated in Table 1. Two bands,  $\lambda_a$ (high  $\epsilon$  value),  $\lambda_b$ (low  $\epsilon$  value), were observed in the spectra of 7-oxo isomers, whereas the 5-oxo isomers showed three bands,  $\lambda_a$ (high  $\epsilon$  value),  $\lambda_b$ (low  $\epsilon$  value) and  $\lambda_c$ (medium  $\epsilon$  value). Substitution at 6-position with chlorine or methylmercapto group caused a large bathochromic shift of b-band in both series.

**Table 1.** U. v. and i. r. spectra of 1,3,4-thiadiazolo [3,2-*a*]pyrimidones.

R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	7-oxo isomer (I)			5-oxo isomer (II)			
			$\nu_{C=O}$	$\lambda_{max}(\epsilon \times 10^{-3})$		$\nu_{C=O}$	$\lambda_{max}(\epsilon \times 10^{-3})$		
			(cm <sup>-1</sup> )	a	b	(cm <sup>-1</sup> )	a	b	c
H	H	H	1610	211(28.5)	262(14.0)	—	—	—	—
Me	H	H	1645	212(21.0)	263(12.4)	—	—	—	—
H	Me	H	1625	212(25.0)	267(11.2)	1680	212(18.1)	248(3.4)	299(6.7)
Me	Me	H	1640	212(26.4)	265(13.8)	1690	214(18.0)	250(3.6)	297(8.6)
Et	Me	H	1640	212(16.1)	265(9.5)	—	—	—	—
SMe	Me	H	1640	213(13.8)	289(13.1)	1705	235(13.0)	270(6.2)	304(9.0)
Cl	Me	H	1625	211(15.7)	275(9.9)	1700	213(11.9)	260(1.5)	301(6.4)
					283(7.6)		219(13.6)		

**Table 2.** N. m. r. spectra ( $\delta$  in p.p.m.) of 1,3,4-thiadiazolo [3,2-*a*] pyrimidones.

7-oxo R <sub>1</sub>	isomer R <sub>2</sub>	(I) R <sub>3</sub>	2-H	5- <i>H</i>	6- <i>H</i>	2- <i>Me</i>	5- <i>Me</i>		
H		H							
H	H	H	9.28	9.65	9.70(d, — J=8Hz)	6.41	6.24(d, J=8Hz)	—	2.59
H	Me	Cl							
Cl	Me Me	H	9.50	—	6.15				2.72
Me	H	H	—	8.51(d, J=8Hz)	6.18(d, J=8Hz)	2.64			2.42
									—
5-oxo R <sub>1</sub>	isomer R <sub>2</sub>	(II) R <sub>3</sub>	2-H	6-H	2- <i>Me</i>	7- <i>Me</i>			
H	Me	H	9.73	6.53	—	2.39			
H		H							
Cl	Me Me	H	9.37	6.32	—	2.45	2.28		
Me	Me	H	—	6.26	2.73	2.30			



Allen *et al.* (1959) reported a considerable difference in the shapes of the absorption curves for 5-oxo and 7-oxo isomers of some of polyazaindenes; the ratio of the extinction coefficients of a longer wave-length band ( $\lambda_c$ ) to that of a shorter wave-length band ( $\lambda_b$ ) was always greater than 1 in 5-oxo series,

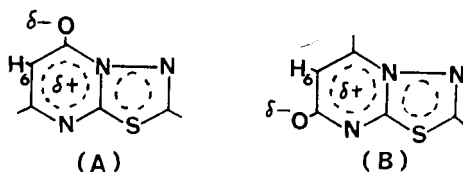
whereas the c-band was at best only one third the intensity of the b-band in the spectra of 7-oxo compounds. The present results are consistent with their findings, although the 7-oxo series of 1,3,4-thiadiazolo[3,2-*a*]pyrimidines showed no/or hardly observable absorption band at the region of c-band.

### B) Infrared absorption spectra

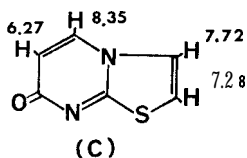
The i.r. spectra of 5*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-5-ones are greatly different from those of 7-oxo isomers, particularly the amide I absorption band for the pyrimidone ring. The 5-oxo compounds showed the band at a region above  $1680\text{ cm}^{-1}$ , whereas the 7-oxo isomers below  $1650\text{ cm}^{-1}$  (Table 1). A similar relation was reported for the spectra of 5-oxo- and 7-oxo-1,2,4,8-tetrazaindenes (Allen *et al.*, 1959). Recently Dunwell and Evans (1971) also found the amide I absorption at the region of  $1625\sim 1640\text{ cm}^{-1}$  for 7*H*-thiazolo[3,2-*a*]pyrimidin-7-ones.

### C) Nuclear magnetic resonance spectra

The chemical shift values for hydrogens on the thiadiazolopyrimidones and of methyl group are enumerated in Table 2. The hydrogens at G-position of 5-oxo isomers resonated at lower magnetic field than those of the corresponding 7-oxo isomers. This suggested that the density of  $\pi$ -electrons on the ring system of 5-oxo isomer might be higher and consequently the diamagnetic ring current could be more effective on the hydrogen at C-6 than the diamagnetic effect in the corresponding 7-oxo isomer. Such resonance hybrids as (A) and (B) would contribute to the n.m.r. of 6-H. The signal displayed from 6-H shifted toward



higher field by substituting 2-position with chlorine and even with methyl group. The methyl hydrogens of 7-oxo isomers (at 5-position) resonated at lower magnetic field than those of 5-oxo isomers (at 7-position); probably owing to anisotropic effect of the neighbouring nitrogens. The hydrogen at C-2 resonated at much lower field than that of the corresponding thiazolo[3,2-*a*]pyrimidine derivative (C) due to the electronegativity of nitrogen (Dunwell and Evans, 1971).



### D) Mass spectra

The mass spectra of many aromatic heterocyclic compounds containing sulfur and nitrogen atoms have recently been discussed (Porter and Baldas, 1971;

Millard and Pain, 1970). The fragmentation of thiazolopyrimidines was well established (Tatematsu *et al.*, 1966). However, there is no report on the mass spectra of thiadiazolopyrimidines. The availability of a number of thiadiazolo-[3,2-*a*]pyrimidine derivatives has prompted us to investigate their mass spectra, primarily in order to distinguish between the 5-oxo and 7-oxo isomers.

The compounds tested generally showed their molecular ion peaks as base peaks.

Secondarily, elimination of CO from their parent ions was a common predominant process. Thirdly, the most of important ions are able to be explained by fragmentation through initially opening the pyrimidone ring, but the little are through opening the thiadiazole moiety; the predominant fragmentation seemed to begin with the pyrimidone ring.

The mass spectra obtained are as followings:

[*m/e* values; intensity (%) in parentheses]

7-Methyl-5*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-5-one (II)

167(100), 139(50), 127(6), 112(40), 109(8), 94(20), 85(33), 71(12), 68(13), 67(14), 58(11), 45(17), 39(41)

2-Chloro derivative of II

203(35), 201(100), 175(19), 173(50), 112(30), 108(20), 94(15), 93(9), 85(18), 79(11), 71(9), 68(6), 67(20), 58(15), 44(24), 39(93)

6-Chloro derivative of II

203(37), 201(100), 175(7), 173(22), 166(5), 146(12), 143(8), 128(8), 126(5), 111(7), 107(5), 105(11), 93(7), 85(17), 73(5), 67(10), 58(9), 45(20), 38(14)

5-Methyl-7*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-7-one (I)

167(100), 139(28), 127(9), 112(8), 109(20), 100(17), 94(9), 85(7), 82(30), 71(7), 68(11), 67(16), 58(8), 54(43), 45(9), 39(22)

2-Chloro derivative of I

203(36), 201(100), 175(8), 173(22), 163(5), 161(14), 112(7), 108(2), 100(6), 95(2), 93(8), 82(28), 79(5), 71(5), 67(9), 54(41), 44(4), 39(23)

2-Methyl derivative of I

181(100), 153(35), 141(5), 112(2), 100(16), 85(6), 82(41), 73(8), 71(14), 67(6), 59(12), 58(8), 54(78)

2-Ethyl derivative of I

195(82), 167(33), 155(10), 137(4), 112(7), 100(8), 85(6), 82(68), 71(22), 67(9), 54(100), 40(40), 27(50)

2-Ethyl-6-chloro derivative of I

231(38), 229(100), 203(25), 201(66), 194(19), 174(4), 156(14), 155(23), 154(34), 148(4), 146(11), 139(9), 116(3), 111(6), 107(11), 105(32), 100(16), 90(9), 88(30), 86(30), 85(16), 73(14), 72(14), 70(14), 62(16)

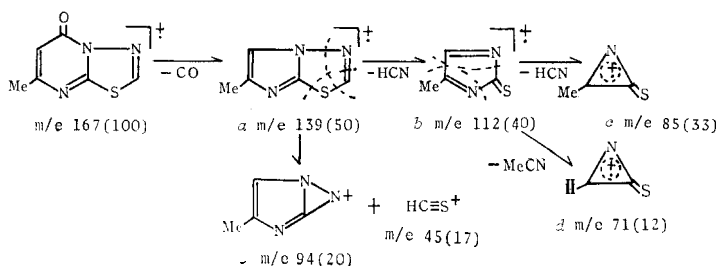
2-Isopropyl derivative of I

209(100), 181(17), 155(8), 112(6), 100(5), 85(4), 82(41), 71(8), 67(6), 54(27)

7*H*-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-7-one

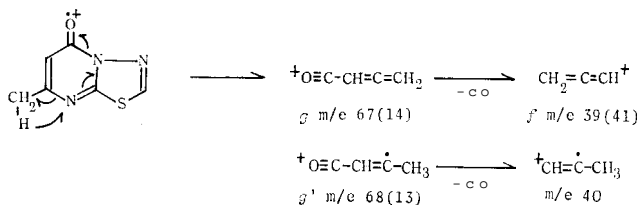
153(100), 127(6), 125(35), 100(14), 95(10), 71(14), 68(30), 58(9), 57(12), 53(8), 45(21), 44(15), 42(15), 40(36)

Schemes 1-9 show tentatively the manner in which 7-methyl-5-oxo- and 5-methyl-7-oxo-thiadiazolo[3,2-*a*]pyrimidine fracture in the mass spectrometer.

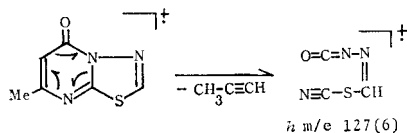


Scheme 1

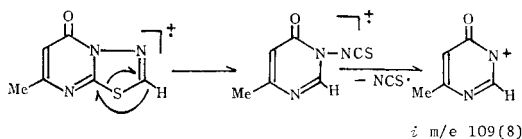
By electron impact to 7-methyl-5H-1,3,4-thiadiazolo[3,2-*a*]pyrimidin-5-one, it expels CO to give an intense ion peak at  $m/e$  139 (a), in turn, the ion loses HCN to yield the ion at  $m/e$  112 (b). Further loss of HCN from the ion *b* furnishes the ion (c) at  $m/e$  85, and of MeCN gives the peak at  $m/e$  71 corresponding to the ion (d). The ion peak at  $m/e$  45 corresponding to  $HCS^+$  may come from the molecular ion and a. Loss of HCS radical from the ion a produces the ion peak at  $m/e$  94 (e). In the second fragmentation path the important ion (f) at  $m/e$  39 results from loss of CO from the ion (g) at  $m/e$  67. The ion g is produced by loss of an aminothiadiazoole radical from the parent ion, accompanying hydrogen transfer. Splitting the pyrimidone ring without hydrogen transfer leads to the ion (g') at  $m/e$  68.



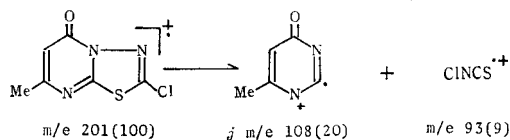
Scheme 2



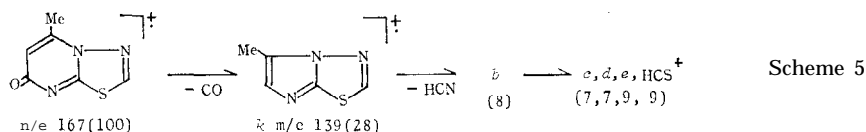
Scheme 3



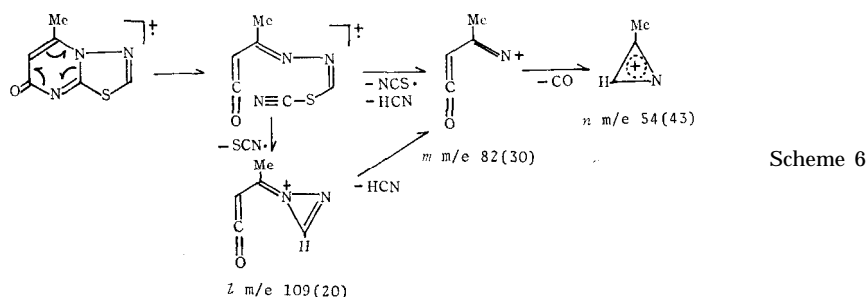
Scheme 4



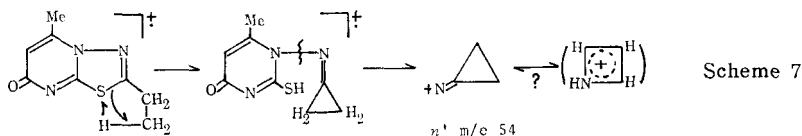
Loss of acetylene in a retro Die&Alder-like reaction produces a less intense peak at  $m/e$  127 (h). An additional fragmentation of the molecular ion is loss of SCN radical accompanying with hydrogen transfer to yield a weak peak at  $m/e$  109 (i). This kind of fragmentation is seemed to be important in the spectrum of 2-chloro derivative, which gives a considerably intense peak at  $m/e$  108 (j) along with the peak at  $m/e$  93 corresponding to the ion  $\text{ClCNS}^+$ .



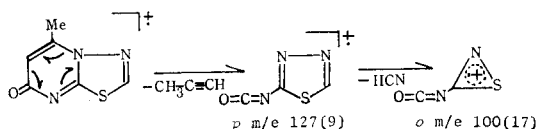
In the spectrum of 5-methyl-7H-1,3,4-thiadiazolo[3,2-a]pyrimidin-7-one, elimination of CO is again predominant. The ion (k) at  $m/e$  139 breaks down to the ions at  $m/e$  112, 94, 85, 71 and 45, corresponding to *b*, *e*, *c*, *d* and  $\text{HCS}^+$ , respectively. However, these peaks are less intense in comparison with the spectrum of the 5-oxo isomer. Loss of SCN radical from the parent ion prominently occurs by accompanying hydrogen transfer or after opening the thiadiazolo-



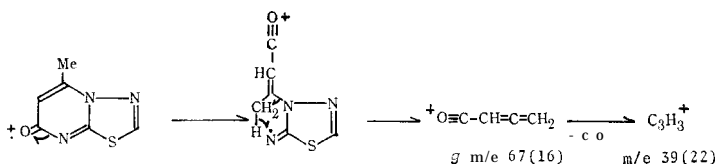
pyrimidone ring to yield the ion (l) at  $m/e$  109, which in turn is led to the ions (m) and (n) corresponding to the intense peaks at  $m/e$  82 and 54, respectively. 2-Ethyl-5-methyl-7H-1,3,4-thiadiazolo[3,2-a]pyrimidin-7-one gives its base peak at  $m/e$  54. This is explained by additional formation of the alternative ion species (*n'*) in such a manner as shown in Scheme 7. These intense peaks at  $m/e$  82 and 54 are characteristic to 5-methyl-7-ones and hardly observed in the spectra of 7-methyl-5-ones.



Another characteristic peak to 7-oxo series is found at  $m/e$  100 corresponding to the ion (o). The ion is produced by eliminating HCN from the ion (p) at  $m/e$  127, which arises from the parent ion by a retro Diels-Alder reaction.



Scheme 8



Scheme 9

## SUMMARY

In the u.v. absorption spectra, main absorption bands of 5-oxo isomers were always found at around 300 nm, whereas 7-oxo isomers showed no band there but at 260~270 nm. This suggested that  $\pi$ -electrons would more be delocalized on the ring system of 5-oxo series than those in 7-oxo series.

In accord with the u.v. spectra, the i.r. absorption spectra indicated that the carbonyl group of 7-oxo isomer considerably polarized than that of 5-oxo isomer. The absorption band due to carbonyl group appeared around 1690  $\text{cm}^{-1}$  in the spectra of 5-oxo isomers, whereas the band always below 1650  $\text{cm}^{-1}$  for 7-oxo isomers.

Proton magnetic resonance spectra showed that the hydrogen on pyrimidine ring (6-H) of a 5-oxo isomer resonated at lower magnetic field than that of the corresponding 7-oxo isomer. This was indicative of higher density of electron on the 5-oxo-pyrimidine ring and consistent with the results from u.v. and i.r. spectra.

In the mass spectrometry, the most of the predominant ions from 5-oxo isomers were explained by a manner, in which the fragmentation began with CO-elimination. A process similar to retro Diels-Alder reaction and fragmentation accompanying hydrogen transfer produced some important ions. In addition to CO-elimination, electron impact to 7-oxo isomers caused predominant loss of thiocyanato radical, leading to important ions. Retro Diels-Alder reaction followed by cyanide elimination furnished the characteristic ion peak at  $m/e$  100 for all of the 7-oxo isomers tested.

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