A NEW TYPE OF HIGHLY POLAR 1,3-DIPOLES. SYNTHESIS AND CHEMISTRY OF THIOCARBONYL-STABILIZED PYRAZOLIDIN-AZOMETHINEIMINES

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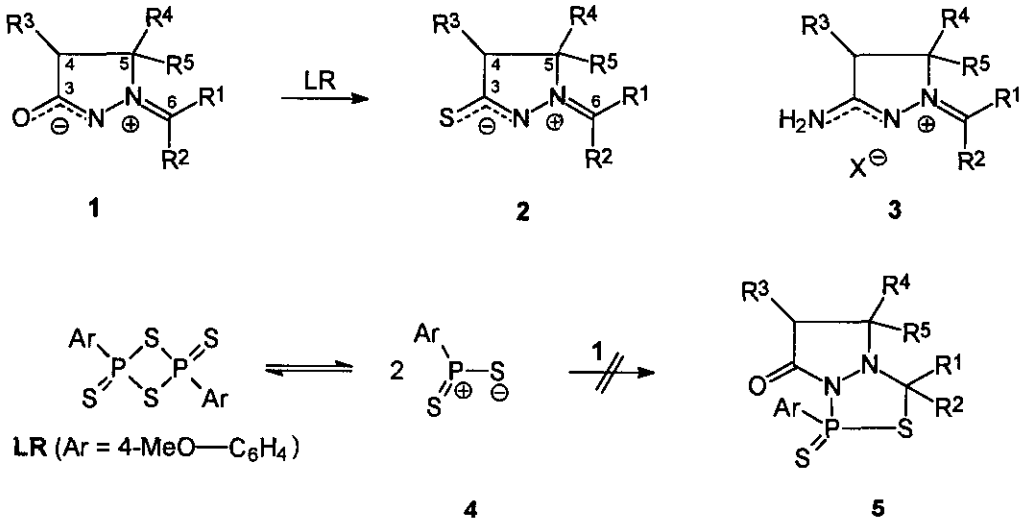
(Dedicated to Prof. Dr. Dr. h. c. mult. A. R. Katritzky, FRS, on the occasion of his 65th birthday)

Abstract - 3-Thioxopyrazolidine-azomethineimines (**2**) are synthesized from their 3-oxo analogues (**1**) and Lawesson's reagent (LR). The electron structures of **1** and **2** resemble those of polymethines, dipole moments of **2** are even higher than those of **1**; further physical organic data are discussed. With $NaBH_4$ **2** gives 3-thioxo-pyrazolidines (**8**). These are *S*-mono- (**10**) and (N-1), *S*-bisalkylated (**11**). *S*-Alkylation of **2** affords pyrazolinium salts (7) 1,3-Dipolar cycloaddition of enamines to **2** results in $[\pi 4_S + \pi 2_S]$ products (**12**, **13**), HOMO/LUMO energies of **1** and **2** are given. Models of γ-thiolactams (**17**, **19**), mimicing antibiotics, are gained *via* 1,3-dipolar cycloadducts of **1** with LR.

From *N,N'*-unsubstituted pyrazolidin-3-ones and carbonyl compounds, the pyrazolidin-3-one-azomethineimines (**1**) are easily obtained,[1a, 2a] from salts of *N,N'*-unsubstituted 3-iminopyrazolidines the immonio analogues (**3**) of (**1**).[1c, 3] Compounds (**1**) and (**3**) are versatile intermediates for syntheses of 1-substituted pyrazolidin-3-ones and 3-imino-pyrazolidines (hydrogenation,[1b, 3] Grignard reaction [4]) and of 3-hydroxypyrazoles (Dorn rearrangement[2b]), and for 1,3-dipolar cycloadditions [2c] We present a related new type (**2**) of thioxo-stabilized azomethineimines



Reaction of 1 mol of azomethineimines (**1**) and 0.5 mol of 2,4-bis(4-methoxyphenyl)-1,3-dithiadiphosphetane-2,4-disulfide (Lawesson's reagent, LR[5]) in dry dichloromethane or benzene at 20-40 °C gives crystalline 1-arylidenepyrazolidin-3-thioxoazomethineimines (**2**) (Table 1,[6]). Analytical data exclude conceivable cycloaddition products (**5**) of the reactive species (**4**) of LR to the 1,3-dipoles **1**, as is known for (P^+- C^-)-systems. [7]

The nmr data (Table 1) confirm the thioxoazomethineimine structure (**2**) and reflect decrease of electron density in the whole system (C-3)-(C-6) of **2**: lower field shift of δ^{13}(C-3), δ^{13}(C-4), δ^{1}(H-4), δ^{13}(C-6) and δ^{1}(H-6), compared to the *O*-azomethineimines (**1**). Deshielding at C-5, typical for the *O*-azomethineimine structure (**1**) versus pyrazolidin-3-ones (**6**), is revealed by δ^{13}(C-5) and δ^{1}(H-5) of the *S*-azomethineimines (**2**) versus 3-thioxopyrazolidines (**8**) as well

The uv vis spectra of the *S*-azomethineimines (**2**) show characteristic strong absorptions at about 400 nm (Table 2), similar to the *O*-azomethineimines (**1**), which absorb at shorter wavelengths (Table 2) After uv irradiation of **2**-solutions in methanol ($3x10^{-5}$M) or in dioxane at 20°C, this absorption completely and irreversibly disappears within 10 minutes. Thus, in case of **2**, we could not observe a typical reaction of an *O*-azomethineimine (**1**), the photochemical isomerisation to a diaziridine with subsequent thermal reversion to **1**.[2b]

In the ir spectra in KBr of **2a**, $\nu(C{=}N^+)$ = 1620 cm^{-1}, and **2d**, $\nu(C{=}N^+)$ = 1603 cm^{-1}, no absorption between 1650 and 1750 cm^{-1} is observed. This agrees with the assignment for the "carbonyl band" in *O*-azomethineimines (**1**).[9]

Table 1. 1-Substituted pyrazolidin-3-thioxoazomethineimines (**2**), 3-thioxopyrazolidines (**8**), disulfide (**9a**), 1-arylidene-3-methyl(benzyl)mercaptopyrazolinium salts (**7**), 1-benzyl- (**10a**) and 1-benzyl-1-methyl-3-methyl-mercaptopyrazolinium iodide (**11a**): analytical, ms and nmr data

	R^1	R^2	R^3	R^4 (R^6)	R^5	mp °C color	$[M]^+$ R_F a)	formula	Anal. C	Calcd/ H	Found N(S)
2a b)	H	Ph	H	H	H	186-188 c) yellow	190 d) 0.57	$C_{10}H_{10}N_2S$	63.12 63.05	5.31 5.30	
2b	H	Ph	Me	H	H	179-183 c) yellow	204 d) 0.68	$C_{11}H_{12}N_2S$	64 66 64.62	5.93 5.85	
2c	H	4-Cl-C_6H_4	H	H	H	179-182 c) yellow	225 d) 0.60	$C_{10}H_9N_2ClS$	53.44 52.94	4.04 4.10	(14.27) (14.42)
2d e)	H	4-MeO-C_6H_4	H	H	H	171-174 c) yellow	220 d) 0.60	$C_{11}H_{12}N_2OS$	59.97 59.74	5.50 5.57	(14.55) (14.34)
2e	H	4-Me_2CH-C_6H_4	H	H	H	182-185 c) orange	232 d)	$C_{13}H_{16}N_2S$	67.19 66.98	6.94 6.97	
2f	H	Ph	H	Me	Me	165-169 c) orange	218 d)	$C_{12}H_{14}N_2S$	66.01 65.48	6.48 6.60	
1g f)	fluorenylidene-(9)		H	H	H	240-245 c) yellow	248	$C_{16}H_{12}N_2O$	77.39 77.51	4.88 4.87	11.28 11.23
2g g)	fluorenylidene-(9)		H	H	H	198-202 c) dark red	264 d)	$C_{16}H_{12}N_2S$	72.69 72 63	4.58 4 71	10.60 10.46
8a h,i)	H	Ph	H	H	H	127-129 white	192 0.55	$C_{10}H_{12}N_2S$	62.45 62.71	6.30 6.38	14 57 14.64
8b	H	Ph	Me	H	H	111-113 white	206	$C_{11}H_{14}N_2S$	64.03 64.17	6.85 6.88	13 58 13.56
8d	H	4-MeO-C_6H_4	H	H	H	122-124 white	222	$C_{11}H_{14}N_2OS$	59.42 59.23	6.36 6.39	12.55 12.55

9a k)	H	Ph	H	H	H	90-91 yellow	383 0.82	$C_{20}H_{22}N_4S_2$	62.78 62.49	5.81 5.90	14.64 14.54
7a l)	H	Ph	H	(Me)		211-214 yellow	332 m)	$C_{11}H_{13}N_2IS$	39.75 39.77	3.95 3.95	(9.65) (9.61)
7b l)	H	Ph	Me	(Me)		163-165 yellow		$C_{12}H_{15}N_2IS$	41.63 41.24	4.37 4.30	8.09n) 7.97
7d l)	H	4-MeO-C_6H_4	H	(Me)		195-198 yellow		$C_{12}H_{15}N_2IOS$	39.78 39.74	4.18 4.22	(8 85)o) (8.89)
7h p)	H	Ph	H	(CH_2Ph)		145 yellow		$C_{17}H_{17}N_2BrS$	56.51 56.26	4.75 4.77	(8.87)q) (8 50)
10a r)						154-157 white		$C_{11}H_{15}N_2IS$	39.52 39.58	4.53 4.55	(9.59)s) (9.61)
11a r)						167-168 white		$C_{12}H_{17}N_2IS$	41.38 41 52	4.93 4.96	8.05t) 8.05

a) tlc (Kieselgel G; EtOH:benzene·$CHCl_3$ = 2:2:1, iodine)· **2** moves faster than **1**, R_F of LR = 0.89. b),e),h),k),r) ^{1}H nmr, 100 MHz, HMDS int. (δ_{Me} = 0.06 ppm) in $CDCl_3$ δ(H-4) = 2.73 (**1a**), 3.29 (**2a**), 2.72 (**1d**), 3.23 (**2d**), 3.54 (**2g**), 2 48 (**6a**) (t, 2H)[18a], 3.02 (**8a**, AA`BB`, J = 8 Hz), δ(H-5) = 4.50 (**1a**), 4.56 (**2a**), 4.47 (**1d**), 4.52 (**2d**), 4.83 (**2g**), 3.30 (**6a**) (t, 2H)[18a], 3.34 (**8a**); δ(H-6) = 7 17 (**1a**), 7 43 (**2a**), 7.13 (**1d**), 7.49 (**2d**) (br s, 1H), 3,.94 (**8a**; s, 2H); in DMSO-d_6 δ(H-4) = 3.06 (**2a**), 2.76 (**1g**); (t, J = 8 Hz, 2H); δ(H-5) = 4.62 (**2a**), 5.02 (**1g**) (t, 2H); δ(R^1 = H) = 8 10 (**2a**; br s, 1H). ^{13}C nmr in $CDCl_3$: δ(C-3) = 184.9 (**1a**), 207.3 (**2a**), 204.8 (**2d**)[8], 174.8 (**6a**), 190.5 (**8a**), 149.6 (**9a**); δ(C-4) = 29.4 (**1a**), 41.8 (**2a**), 41.9 (**2d**)[8], 30.0 (**6a**), 42 6 (**8a**), 35.8 (**9a**); δ (C-5) = 57.9 (**1a**), 58.4 (**2a**), 57 4 (**2d**)[8], 51.3 (**6a**), 53 0 (**8a**), 53.7 (**9a**); δ(C-6) = 132 7 (**1a**), 135.0 (**2a**), 136 3 (**2d**)[8], 63.5 (**6a**), 62.4 (**8a**), 60 4 (**9a**). ^{13}C nmr in CD_3OD. δ(C-3) = 182.2 (**10a**), 179.5 (**11a**); δ(C-4) = 39.9 (**10a**), 38.3 (**11a**); δ(C-5) = 49.7 (**10a**), 59.9 (**11a**); δ(C-6) = 62 6 (**10a**), 69.5 (**11a**), δ(S-Me) = 15 1 (**10a**), 13.0 (**11a**); δ(N^+-Me) = 52.9 (**11a**). c) decomp ; after evaporation of solvent the residue is treated with boiling anhydrous MeOH or EtOH, on cooling 50-80% needles or platelets. d) in the mass spectra (HP 5985 B, 70 eV) besides the molecular ion $[M]^+$ the characteristic fragmentation ions at m/z = $[M-S]^+$, $[M-SH]^+$, $[M-(CHR^3-CR^4R^5)]^+$, $[R^1R^2C{=}N{-}N]^+$ and $[R^1R^2C{=}N]^+$ are found. i) solution of **8a** in 1 N NaOH, evaporation of water and crystallisation from i-PrOH gives **8a**-Na·3H_2O, mp (decomp.) 200-210 °C. l) X = I m) besides $[M]^+$, $[I]^+$, $[MeI]^+$, $[M-I]^+$ and $[M-MeI]^+$ the fragmentation ions of **2a** are found n) I calcd/found: 36.65/36.90. o) I calcd/found: 35 19/35.37. p) X = Br, above 145 °C thermally instable. q) Br calcd/found: 22 11/22.45. s) I calcd/found: 37 97/37.84. t) I calcd/found: 36 43/36.62.

Table 2 Uv vis data [a] and dipole moments of pyrazolidin-3-one-azomethineimines (**1**) and pyrazolidin-3-thioxo-azomethineimines (**2**)

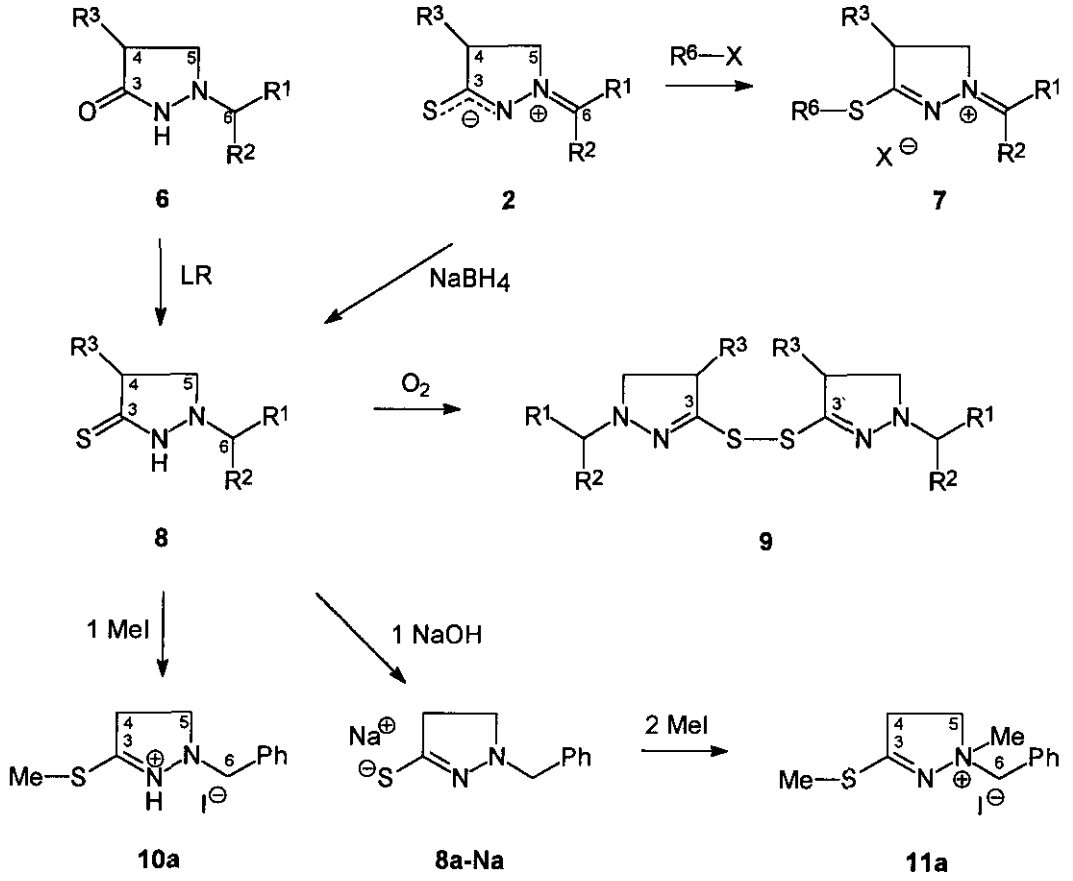
	R^1	R^2	R^3	R^4	R^5	λ_{max} [nm]		ε 10^{-3} b)		μ c)	
						1	**2**	**1**	**2**	**1**	**2**
1a, 2a	H	Ph	H	H	H	325, 339	391	30.8, 28.0	26.3	6 8	
1b, 2b	H	Ph	Me	H	H		394		26.0	6.9	8.1
1c, 2c	H	4-Cl-C_6H_4	H	H	H		400		26.9	7.0	
1d, 2d	H	4-MeO-C_6H_4	H	H	H	337, 351	400	35.8, 32.4	31.8	6.9	
1e, 2e	H	4-Me_2CH-C_6H_4	H	H	H		393		30.0	6.4	8.2
2f	H	Ph	H	Me	Me		393		25.1		
2g	fluorenylidene		H	H	H		455		28.9		

a) most intense absorption. b) $3x10^{-5}$ in MeOH, after 4 days in the dark at 20 °C unchanged. c) μ [D] (± 2%) was measured in dioxane at 25 °C according to the method, described in ref. 10, by Prof. Dr. G. Oehme, Univ Rostock, and Th. Kreher.

Although simple thiocarbonyl compounds ought to be less polar than the corresponding carbonyl compounds (aliphatic thioketones/ketones), this is not valid in the presence of donor substituents. The thiocarbonyl group (2p-3p-π overlap) *is a better π-acceptor than the carbonyl group* (2p-2p-π) and has the greater polarizability during interaction with π-donors or π-acceptors. The *O*-azomethineimines (**1**) show unusual high dipole moments (μ = 6.4 - 7.0 D), but their *S*-analogues (**2**) are even more polar (μ = 8 1 - 8.2 D) (Table 2). Generally 1,3-dipoles must not be polar; another exception is the azomethineimine fluorenyliden=N^+(4-Br-C_6H_4)-N^--CN with μ = 6.7 D (dioxane, 25°C [11]).

Molecular geometry data, as well as nmr values,[8] *suggest that* the electron structure of thioxoazomethineimines (**2**) is very similar to that of their oxo analogues (**1**) According to CNDO/2-calculations,[12] the distribution of valence electrons in pyrazolidin-3-one-azomethineimines (**1**) resembles that of a polymethine system. An out-balancing of bond lengths is characteristic of the azomethineimine systems in **1** and in **2**. In the planar system X-(C-3)-(N-2)-(N-1)-(C-6) of the *O*-azomethineimine (**1d**) (X=O) the bond lengths are: O-(C-3) = 1.23, (C-3)-(N-2) = 1 34, (N-2)-(N-1) = 1.37, (N-1)-(C-6) = 1.29 Å.[13] *The corresponding X-ray crystallographic data for*

the *S*-azomethineimine (**2a**) (X=S) are· S-(C-3) = 1.66, (C-3)-(N-2) = 1.34, (N-2)-(N-1) = 1.37, (N-1)-(C-6) = 1.30 Å, all atoms in one plane, too. We point to the striking fact, that the (C-O)-bond length in *O*-azomethine-



imines (**1**) corresponds to that of ketones, what (after interesting discussions with H D.) led S. Kulpe[14] to the term "polymethinic carbonyl". Similarly the (C-S)-bond length in the *S*-azomethineimine (**2a**) corresponds to that of 5-(4-chlorophenyl)-1,2-dimethyl-3-thioxopyrazolidine· S-(C-3) = 1.67, (C-3)-(N-2) = 1.31, (N-2)-(N-1) = 1.44 Å[15] and of **12**. Theoreticians should think about the term "polymethinic thiocarbonyl" in type (**2**)

Hydrogenation of thioxoazomethineimines (**2**) with sodium borohydride in methanol affords colourless 3-thioxo-pyrazolidines (**8**) (Table 1) in high yields, if decomposition of $NaBH_4$ is avoided, otherwise yellow disulfides (**9**) are generated as by-products. 1-Benzylpyrazolidin-3-one (**6a**) with 0 5 mol LR in dichloromethane (10 h, 20 °C; 30% yield) as well as 1-benzylidenepyrazolidin-3-thioxoazomethineimine (**2a**) with 1.2 mol $NaBH_4$ in methanol

(20 °C; 90% yield) gave 1-benzyl-3-thioxopyrazolidin (**8a**) In aqueous alkaline solution **8a** remains unchanged by oxygen (8 h, 50 -70 °C), whereas in methanol at 20 °C **8a** is oxidized by air to **9a**

Table 3. r-5-Phenyl-c-8a-morpholino-c-5a*H*-perhydrocyclopenta[*c*] (**12**) and r-5-phenyl-c-9a-morpholino-c-5a*H*-perhydrocyclohexa[*c*]pyrazolo[1,2-*a*]pyrazol-1-thione (**13**), dimethyl 3-phenyl- (**17a**) and dimethyl 3,3-dimethyl-7-thioxo-5,6-dihydropyrazolo[1,2-*a*]pyrazol-1,2-dicarboxylate (**17i**), r-1-phenyl- (**19a**) and r-1-(4-methoxyphenyl)-c-2-nitro-t-3-phenyl-5-thioxoperhydropyrazolo[1,2-*a*]pyrazol (**19d**): analytical, ms and nmr data [a]

	R^1	R^2	mp °C color	$[M]^+$ R_F	formula	Anal. C	Calcd/ H	Found N
12 [b]			160-162 white	343 0.85 [c]	$C_{19}H_{25}N_3OS$	66.43 66.47	7 35 7 38	12.23 12.25
13 [b]			170-176 [d] yellow	 0 82 [c]	$C_{20}H_{27}N_3OS$	67.18 67.20	7.63 7.81	11.75 11.78
16h [e]	$(CH_2)_2CO_2H$	Me	173-175 yellow	326	$C_{14}H_{18}N_2O_7$	51.52 51 67	5.57 5.63	8 59 8.55
17a [f,g]	Ph	H	123-124 orange	332 [h] 0.81 [i]	$C_{16}H_{16}N_2O_4S$	57.81 57.72	4 86 4.86	8.43 8.38
17i [f]	Me	Me	129-131 orange	 0.74 [i]	$C_{12}H_{16}N_2O_4S$	50 68 51.07	5.68 5.78	9 85 9 71
19a [k]	Ph		163-166 greenish		$C_{18}H_{17}N_3O_2S$	63.69 63.54	5 06 5.04	12.38 12.26
19d [l,m]	4-MeO-C_6H_4		188-191 green	369 [n]	$C_{19}H_{19}N_3O_3S$	61.76 61.80	5 19 5.21	11.38 11 32

a) foot notes g) and m) give for comparison ^{13}C nmr data of two oxo-/thioxo-pairs **16a/17a** and **18d/19d**. b) from **2a** and 1.3 mol of 1-morpholinocyclopentene (**12**) resp. -cyclohexene (**13**) in boiling benzene, 10 h, evaporation, chromatography on neutral Al_2O_3 in CH_2Cl_2, recryst. from EtOH or MeOH (for X-ray measurements), 45% c) tlc (Kieselgel G; iodine) in EtOH:benzene.$CHCl_3$ = 2:2:1 . d) decomp. e) from **1h**[17] and 1.25 mol of methyl acetylendicarboxylate in boiling chlorobenzene, 13 h, recryst. EtOH, 70%. f) from **16a** resp. **16i**[18a] and 0.5 mol of LR in CH_2Cl_2, 20 h, 25 °C, evaporated, triturated with Et_2O, recryst. MeOH. g) δ ^{13}C in $CDCl_3$ [in ( ) data of **16a**] : (C-1) = 135 8 (138 0), (C-2) = 122 9 (115.6), (C-3) = 72.5 (73.9), (C-5) = 50.6 (51.7), (C-6) = 48.9 (35.2), (C-7) = 183.1 (165 2), C-9) = 162.1 (162.7), (C-10) = 159.3 (159.6), (O-Me) = 53.5, 52 1 (53 4, 51.7) ppm. h) in ms of **16a** and of **17a** besides $[M]^+$ a characteristic fragmentation ion at m/z =

$[CH_2=CH-C=X]^+$ is found. i) tlc in $MeNO_2$, R_F = 0 66 (**16a**), 0.52 (**16i**). k) from **18a**[18b,c] and 0.65 mol of LR in boiling benzene, 5 h, cooled, filtrated from LR, evaporated, recryst. ethyl acetate-Et_2O, 90%. l) from **18d**[19c] and 0.5 mol of LR in CH_2Cl_2, 20 h, 25 °C, evaporated, residue treated with boiling EtOH and MeOH, 75%. m) $\delta^{13}C$ in $CDCl_3$ [in ( ) data of **18d**]: (C-1) = 68 4 (70.3), (C-2) = 98.3 (99.4), (C-3) =.61.9 (59.7), (C-5) = 181.1 (165.5), (C-6) = 48.3 (35.7), (C-7) = 49.6 (49.2) ppm n) in ms of **18d** and **19d** besides $[M]^+$ characteristic fragmentation ions at m/z = $[M - (Ph-CH=CH-NO_2)]^+$, $[M - (4-MeO-C_6H_4-CH=CH-NO_2)]^+$ and $[CH_2=CH-C=X]^+$ are found.

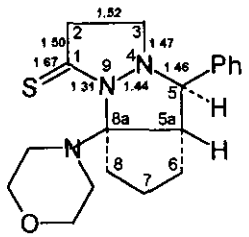
3-Thioxopyrazolidines (**8**) easily form crystalline sodium salts. The nmr data (Table 1) reflect additional deshielding at (C-3) and (C-4) of thioxopyrazolidines (**8**) compared to their oxo analogues (**6**).

Alkylation of *O*-azomethineimines (**1**) gives rise to a mixture of secondary products.[16] We anticipated that the greater polarizability of the thioxo group in *S*-azomethineimines (**2**) would promote selective attack of an electrophile at *S*. Thus reaction of thioxoazomethineimines (**2**) with methyl iodide in boiling methanol or with benzyl bromide in boiling ethanol afforded yellow pyrazolinium salts (**7**) (Table 1) in high yields. The *S*-methylation of **7a** was confirmed by X-ray crystallography.[19a]

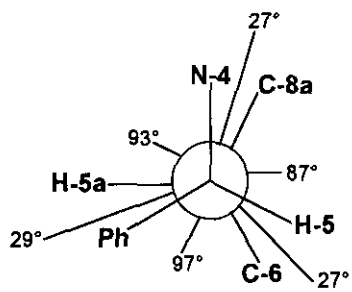
While 1-substituted pyrazolidin-3-ones (**6**) in benzene, acetone and alkohols are alkylated at (N-1),[20] the 3-thioxopyrazolidines (**8**) , depending on the conditions, can be *S*-monoalkylated (**10**) or (N-1), *S*-bisalkylated (**11**). **8a** with 1 mole methyl iodide in boiling methanol gives the pyrazolinium iodide (**10a**), the sodium salt of **8a** with 2 moles methyl iodide in methanol **11a,** both in more than 90% yield. (N-1), *S*-bisalkylated pyrazolinium salts (**11**) can also be gained by reaction of *S*-monoalkylated salts (**10**) with 1 mol alkyl halide and addition of one equivalent base in methanol The *S*-monoalkylation of **10a** is confirmed by ^{13}C nmr data: δ(S-Me) and absence of deshielding at C-5 and at C-6 The (N-1), *S*-bisalkylated structure (**11**) was also assigned by ^{13}C nmr· for **11a** deshielding at C-5 and typical signals for S-Me, N^+-Me and N^+-(C-6) were found (Table 1). In the model $[MeS-CH=NMe_2]^+ FSO_3^-$ $\delta^{13}C$ comparatively is 16 7 (S-Me), 42.2 and 48 9 (N^+-Me), 183.3 ppm (C=N).

Like *O*-azomethineimines (**1**) the *S*-azomethineimines (**2**) should react as 1,3-dipoles According to MNDO calculation[19b] the frontier orbital energies are for **1** [**2**] (R^1-R^5= H) -8.79 [-8.18] (HOMO) and -0.53 [-1.02] (LUMO) eV. Cycloadditions of dipolarophiles to azomethineimines should obey the "Sustmann I" ($HOMO_{dipole}$)- or the "Sustmann II" ($HOMO_{dipole}$ or $LUMO_{dipole}$, depending on substituents)-type[21] of HOMO-LUMO interactions, whereby the *S*-azomethineimines (**2**) should react faster than their *O*-analogues (**1**). Yet we isolated in about 50% yield the cycloadducts (**12**) and (**13**) of enamines (Table 3) According to X-ray analysis the stereochemistry of **12** meets that of a $[\pi 4_s + \pi 2_s]$ reaction product. The bond lengths S-(C-1)-N-N resemble those of 3-thioxopyrazolidines (see above,[15]).

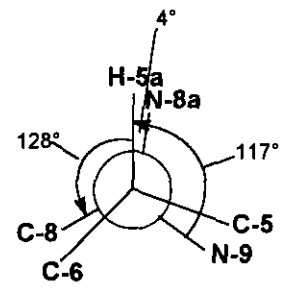
Cycloaddition of propiolates or vinylsulfones to pyrazolidin-3-one-azomethineimines (**1**) led to an exciting new type (**14**) (R = NH-CO-R' or CH(OH)Me)[22] of γ-lactam-antibacterials, that mimic β-lactam-antibiotics We *claimed sodium salts* of **18** as antibacterials and studied the reaction of pyrazolidin-3-one with formaldehyde [23] Presumably the acylating capacity of γ-thiolactams (**15**) will surpass that of γ-lactams (**14**). Thus we endeavoured to synthesize γ-thiolactam models (**17**) and (**19**).



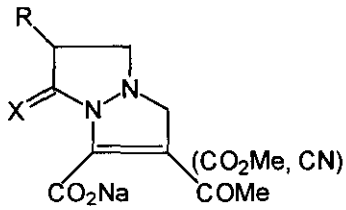
12
13: cyclohexa[*c*]-homologue of **12**

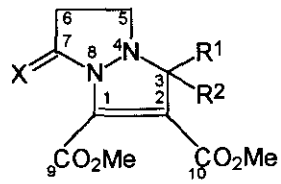


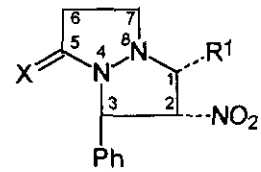
Newman projection
12 (C-5)-(C-5a)



Newman projection
12 (C-5a)-(C-8a)







X = O: **14** **16** **18**
X = S: **15** **17** **19**

While cycloaddition of dimethyl acetylendicarboxylate or β-nitrostyrene to thioxoazomethineimines (**2**) proved an inadequate method to get **17** or **19**, with LR substitution of the γ-lactam-(C=O) in **16** and in **18** by (C=S) was successful (Table 3) ^{13}C *Nmr data confirm the selective O/S-exchange* at C-7 in the dicarboxylates **16a/17a**: characteristic deshielding at C-7 and at C-6 as well as two unaffected CO_2Me in **17a**. Deshielding at C-5 and at C-6 is also valid for the thioxo compound (**19d**) compared to its oxo analogue (**18d**) (Table 3). This agrees with the appearance of the fragment $[CH_2=CH-C=X]^+$ in the ms of **16a**, **18d** (X=O) *and* **17a**, **19d** (X=S). Thus γ-thiolactams of type **15** can be acquired *via* γ-lactams (**14**).

EXPERIMENTAL

1-Substituted 3-thioxopyrazolidines (8). To a stirred suspension of 3.81 g (20 mmol) of **2a** in 80 ml of MeOH 946 mg (25 mmol) of $NaBH_4$ are added at 20°C, the then colourless solution filtered, evaporated and the residue dissolved in 35 ml of water. If yellow disulfide should be formed, **9a** can be extracted with CH_2Cl_2. Addition of mineral acid up to pH 5 deposits **8a**, which is recrystallized from MeOH or EtOH, yield 91.5% **8b**, **8d** and 1-(3,4-dimethoxybenzyl)-4-methyl-3-thioxopyrazolidine, mp 140-142 °C, were prepared analogously.

Alkylation of 1-arylidene-3-thioxopyrazolidinazomethineimines 2 to 7a-7h. To 1 90 g (10 mmol) **2a** in 45 ml of dry boiling MeOH 2.13 g (15 mmol) of MeI in 10 ml of dry MeOH are added within 3 h. After further 5 h refluxing, removing of about 30 ml of MeOH and cooling crystalline **7a** deposits, which is treated with 20 ml boiling EtOH; after cooling 86,1% **7a**. **7b** and **7d** were prepared analogously.

To a suspension of 1.9 g (10 mmol) of **2a** in 50 ml of dry boiling EtOH 1.31 ml (11 mmole) of benzyl bromide in 10 ml of dry EtOH are added within 30 min. The then solution after further 90 min refluxing is evaporated, the residue treated with 15 ml of dry i-PrOH and the yellow crystals of **7h** recrystallized from EtOH, 70% yield The pyrazolinium salts (7) stand drying at 80 °C, **7h** begins to decompose above 145 °C.

Alkylation of 3-thioxopyrazolidines 8. 1.92 g (10 mmol) of **8a**, 1.42 g (10 mmol) of MeI and 30 ml of dry MeOH are refluxed for 2 h, evaporated and the residue recrystallized from dry i-PrOH, 92.3% **10a**.

3.85 g (20 mmol) of **8a** are dissolved in 20 ml of 1N NaOH (50-60 °C), evaporated and the residue recrystallized from i-PrOH, 94% of **8a-Na**·3 H_2O. To the solution of 2 68 g (10 mmol) of **8a-Na** ·3 H_2O in 30 ml of MeOH 2 84 g (20 mmol) of MeI are added, after 25 h at 25 °C evaporated and the residue recrystallized (filtered) from n-PrOH, 92 3% **11a**. Similarly from **8a-Na**·3 H_2O and benzyl bromide in MeOH, 3 days at 25 °C, 1,1-dibenzyl-3-benzylmercaptopyrazolinium bromide, $C_{24}H_{25}BrN_2S$, mp 183-185 °C, recryst. from i-PrOH, is obtained.

1.67 g (5 mmol) of **10a**, 0 71 g (5 mmol) of MeI, 0 26 g (2.5 mmol) of Na_2CO_3 or 0.42 g (5 mmol) of $NaHCO_3$ and 30 ml of MeOH are stirred for 5 days at 25 °C, filtered, evaporated, the residue dissolved in boiling i-PrOH, filtered and cooled, 81% colourless needles of **11a**.

Further details are summarized in Tables 1 and 3

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