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OPEN-CHAIN ALIPHATIC THIONES AND DIAZOMETHANE; REACTIONS OF 1,3,4-THIADIAZOLINES AND THIOCARBONYL YLIDES [1]

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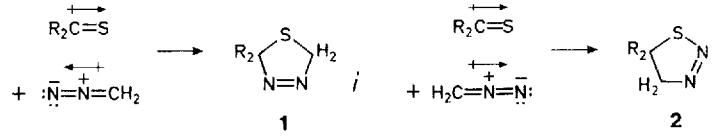
Summary Diazomethane adds in two directions to $R_2C{=}S$, R = ethyl, propyl, isopropyl, *tert*-butyl; the dependence of the regioisomer ratio on R and on solvent polarity discloses the nature of the orienting forces. The thione-*S*-methylides generated by N_2 extrusion from 1,3,4-thiadiazolines undergo 1,4-H shift or electrocyclization.

According to an ab initio calculation (3-21G*), the polarity of the double bond in $H_2C{=}S$ is negligibly small, and the dipole moment must arise from H-C polarity and the lone pair contribution.[3] Both the carbon and sulfur atoms of thioketones are electrophilic.[4] The product of adamantanethione and diazomethane showed two ^{1}H NMR singlets, and their assignment to the spiro-1,3,4-thiadiazoline 3 and the 1,2,3-isomer was suggested by Krapcho et al.;[5] the ratio of the regioisomers depends on solvent polarity and varies from 87:13 in petrol ether to 22:78 in methanol.[6] We separated the regioisomeric cycloadducts and established their structures.[7]



We treated thioketones, $R_2C{=}S$, R = ethyl, propyl, isopropyl, and *tert*-butyl, in three solvents with gaseous diazomethane at 0°C and attributed the singlets at δ_H 5.54-5.82 to the 2,2-dialkyl-1,3,4-thiadiazolines (1) and the more shielded ones at 4.75-4.77 ($CDCl_3$) to the 1,2,3-isomers 2 (Table 1).

The high stereospecificity [8] and other mechanistic criteria [9] favor *concertedness* for the 1,3-dipolar cycloadditions of diazoalkanes to electron-deficient C=C bonds; additions of diazomethane to C=S bonds are probably likewise concerted. Thiones are "superdipolarophiles" as reported recently.[10]

The data of Table 1 allows one to disentangle some of the orienting forces. The decrease of the ratio 1/2 with rising solvent polarity intimates that the transition states leading to the 1,2,3-thiadiazolines 2 are more polar than the ones furnishing 1. The dipole moments in the orientation complex producing 1 partially cancel each other, but reinforce on the pathway

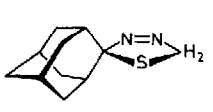
Table 1. Cycloadditions of diazomethane to dialkyl thioketones at 0°C; ratio of regioisomeric thiadiazolines 1/2 (^{1}H NMR analysis)

$R_2C=S$	*Solvent*	Pentane	Diethyl ether	Methanol
R:	CH_2CH_3	75:25	62:38	13:87
	$CH_2CH_2CH_3$	77:23	73:27	19:81
	$CH(CH_3)_2$	87:13	85:15	40:60
	$C(CH_3)_3$	100:0	100:0	100:0
R_2C:	Adamantylidene	91:9	80:20	26:74

to 2; thus, the *electrostatic disadvantage* of 2 formation is mitigated in solvents of high polarity. The empirical parameters of solvent polarity, E_T,[11] indicate a small gap between pentane (32.4 kcal mol^{-1}) and diethyl ether (34.6), but a big one from the latter to methanol (55.5).

The linking of the substituted C-atoms in the formation of 2 is hindered by increasing *steric demands* of the thione substituent R. The ratio 1/2 rises - in methanol even dramatically - and the formation of 1 is uncontested for di-*tert*-butyl thioketone.

Both these effects favor 1. But which orienting influence is responsible for 1/2 = 13:87 in the case of diethyl thioketone + diazomethane in methanol ? The *second-order term of the perturbation equation* contains the attractive forces in the transition state and is larger for the concerted formation of 2 than for 1. Thioformaldehyde shows AO coefficients of 0.68 (C) and -0.57 (S) in the π-LU, and the difference grows with C-alkylation (3-21G).[12] The terminal AO coefficients of the π-HO of diazomethane amount to 0.78 (C) and -0.61 (N).[13] Thus, the C-C linking (→ 2) supplies the biggest product of coefficients. The interaction HO(diazomethane) - LU(thione) is probably dominant on the basis of MO energies. Moreover, the second FMO pair contributes little to the regioselection, since AO coefficients are smaller and more alike in LU(CH_2N_2) and HO(thione).



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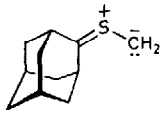

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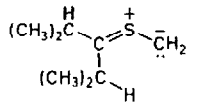

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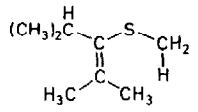

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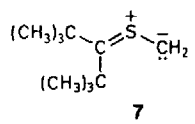

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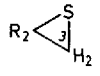

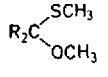

8 R: $CH(CH_3)_2$ **10**

9 R: $C(CH_3)_3$ **11**

Table 1 suggests that adamantanethione resembles diisopropyl thioketone in steric demand. Adamantanethione is still capable of forming a dimer [14] in contrast to the more hindered thiones like thiofenchone [15] and α,α,ω,ω-tetramethylcycloalkanethiones.[16] The latter combine with diazomethane furnishing 1,3,4-thiadiazolines only. The more bulky the substituents, the greater the stability of thiones in the monomeric state - and the less overpowering the odor.

In the course of the N_2 extrusion of 1,3,4-thiadiazolines - a 1,3-dipolar cycloreversion - 90° rotations about the two C-S bond axes give rise to the planar 4π bond system of the thiocarbonyl ylide. The N_2 elimination proceeds the faster, the better the resulting dialkyl-thione-*S*-methylide *approaches planarity*. This is easier for adamantanethione-*S*-methylide (4) than for 5 and 7.

The half-reaction times of the following 1,3,4-thiadiazolines indicate that the transition states of N_2 loss decreasingly profit from the bond energy of the incipient *S*-methylides:

3	$t_{1/2}$ =	78 min at 40°C, 32 min at 46°C in xylene
		108 min at 40°C in acetonitrile;
1, R = $CH(CH_3)_2$		24 min at 70°C in toluene,
		30 min at 70°C in acetonitrile;
1, R = $C(CH_3)_3$		29 min at 100°C in xylene.

According to ^1H NMR analysis ($CDCl_3$) with standard, thermolysis of 1, R = $CH(CH_3)_2$ (mp -12 to -10°C),[17] in toluene afforded enethiol ether 6 and thiirane 8 in 65:35 ratio; due to losses on evaporation of the toluene, the yield is only 71%. In acetonitrile at 70°C, 8 is the major (80%) and 6 the minor product (11%). A symmetry-allowed *suprafacial 1,4-H shift* offers an attractive pathway for 5 → 6 with the *electrocyclization* 5 → 8 competing. When 5 was generated in methanol (12 h 60°C), ^1H NMR analysis indicated 91% of the *O,S*-dimethyl acetal 10, the methanol adduct.

Thick-layer chromatography allowed separation of 6 and 8. Enethiol ether 6 is a colorless, intensely smelling oil (bp 90°/10). The ^1H NMR spectrum ($CDCl_3$) reveals an isopropyl group at δ 0.97 (d, J = 7 Hz) and 3.00 (sept), whereas singlets at 1.79, 2.02, 2.07 were recorded for the methyls at the unsaturated center and SCH_3. The olefinic C-atoms appear at δ_C 136.5 and 137.0, and SCH_3 as q at 23.5. The likewise oily thiirane 8 (bp 40°C/10) is characterized by ^1H doublets at δ 0.95 and 1.00 for diastereotopic pairs of methyl groups and by s 2.30 for 3-H_2. The acetal 10, δ_H 1.92 (SCH_3) and 3.30 (OCH_3), eliminated methanol on silica gel affording 6.

The stabilization by 1,4-H shift is not open to di-*tert*-butyl thioketone-*S*-methylide (7). After decomposition of 1, R = $C(CH_3)_3$ (mp 64-65°C), in toluene

ne at 100°C and removal of the solvent, the singlet at δ_H 2.34 (3-H_2) pointed to 73% of thiirane 9 (6 CH_3 s 1.15). When 7 was liberated from 1, R = $C(CH_3)_3$, in methanol at 110°C (1.5 h), acetal 11 was not found; 23% 9 constituted the only clearly defined product.

The difference in behavior of 1,3-dipoles 5 and 7 in cycloaddition reactions - following communication - reveals mechanistic divergences.

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