Heteroatom Chemistry
Volume 17, Number 5, 2006

Dichotomy of 1,3-Dipolar Cycloreversions in a Tetrasubstituted 2,5-Dihydro-1,3,4-thiadiazole

Elke Langhals and Rolf Huisgen

Department Chemie und Biochemie der Ludwig-Maximilians-Universität München, Butenandtstr. 5-13, D-81377 München, Germany

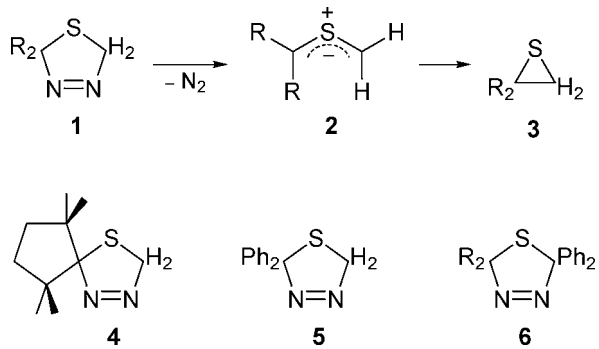
Received 2 January 2006; revised 6 February 2006

ABSTRACT: *The cycloaddition of diphenyldiazomethane (**8**) to 16 thioketones at 40°C which furnishes tetrasubstituted 2,5-dihydro-1,3,4-thiadiazoles, is followed by rapid N_2 loss (see the preceding paper), with one exception: For the dihydrothiadiazole **10**, the N_2 extrusion is slower by a factor of 4900 than its formation from **8** and 2,2,6,6-tetramethycyclohexanethione (**7**). This elimination of N_2 is a 1,3-dipolar cycloreversion which affords a thiocarbonyl ylide + N_2 As a consequence of steric hindrance in the example of **10**, a concomitant second cycloreversion furnishes thiobenzophenone (**12**) and the diazocyclohexane derivative **13** in an equilibrium. The complex kinetic system of Scheme 2 is confirmed by the irreversible interception of **13** with thioketone **14**. The structural conditions for retarded N_2 extrusions from dihydrothiadiazoles are discussed.* © 2006 Wiley Periodicals, Inc. Heteroatom Chem 17:443–448, 2006; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/hc.20263

INTRODUCTION

The rate of thermal extrusion of N_2 from 2,5-dihydro-1,3,4-thiadiazoles (**1**) shows a high dependence on the substitution pattern. The gain in bond energy during the conversion of the cyclic azo compound **1** into the N_2 molecule affords the thermodynamic driving force, but also the substituted thiocarbonyl ylide (**2**) affects the energy level of the transition state (TS), as summarized in the preceding paper [1].

The first-order rate constant of N_2 elimination exhibits nearly the same numerical value for the sterically hindered tetramethylcyclopentane-spiro-compound **4** at 45°C as for the 2,2-diphenyl derivative **5** at –45°C (Scheme 1) [2,3]; that corresponds to a decrease of the activation free energy by 7 kcal mol^{-1} as a consequence of the gain in conjugation.



SCHEME 1

1,3-Dipolar Cycloadditions, 134; for part 133 see [1] (the preceding paper). Dedicated to the memory of Günther Ohloff, Bern, Switzerland.

Correspondence to: Rolf Huisgen; e-mail: Rolf.Huisgen@cup.uni-muenchen.de

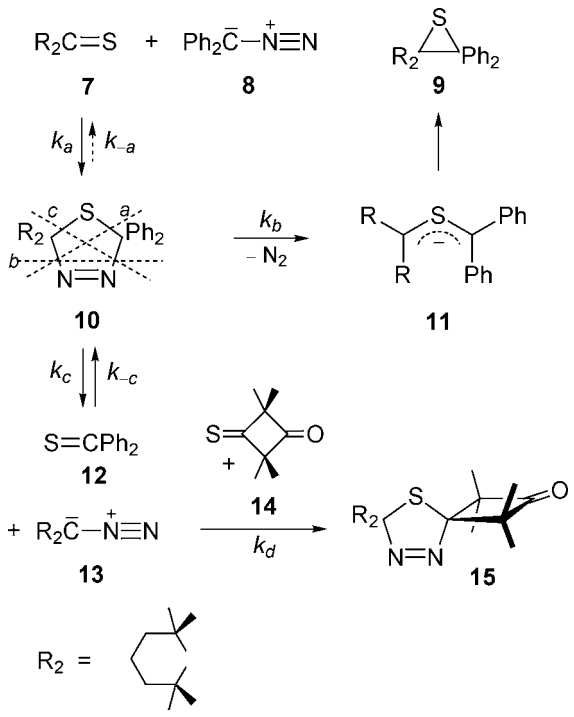
Present address of Elke Langhals: Consortium für Elektrochemische Industrie, Wacker Chemie GmbH, Zielstattstr. 20, D-81379 München, Germany.

The process of N_2 elimination from dihydrothiadiazoles **1** looks deceptively simple. In this 1,3-dipolar cycloreversion, we face the same structural changes that characterize concerted 1,3-dipolar cycloadditions and Diels–Alder reactions. The loosening of the two C—N bonds is synchronized with two 90° rotations about the C—S bonds generating the planar thiocarbonyl ylide **2**, a 1,3-dipole. The resonance energy of the parent thiocarbonyl ylide **2**, R = H, amounts to 19.3 kcal mol^{-1}, as calculated from the rotational barrier with UB3LYP/6-31G* [4].

Not only the gain in conjugation becomes perceptible in the rate of nitrogen extrusion; steric factors exerted by voluminous substituents may decelerate the process. The cycloaddition of diphenyldiazomethane (**8**) to thioketones at 40°C furnishes tetrasubstituted 2,5-dihydro-1,3,4-thiadiazoles **6** [1]; as a consequence of substitution by phenyl, they eliminate N_2 in a fast subsequent cycloreversion. There was one exception among 16 studied examples: the adduct **10** resulting from **8** and 2,2,6,6-tetramethylcyclohexanethione (**7**) was isolable (Scheme 2).

SEVERAL PATHWAYS OF CYCLOREVERSION

When the reactants **7** and **8** were combined in ether at room temperature, the crystalline dihydrothiadiazole **10** was isolated (66% yield) and characterized. In benzene solution at 50°C, the N_2 elimination of **10** became observable. After 24 h at 50°C, the ^{1}H NMR analysis with weight standard indicated the tetrasubstituted thiirane **9** in 81% yield.



SCHEME 2

The NMR parameters confirm the structure. Five ^{13}C doublets for aromatic CH and one singlet for two aromatic C_q display isochronous, but rotationally hindered, phenyl groups. The mass spectrum of **9** presents —besides the loss of sulfur and alkyl—the radical anion of thiobenzophenone (*m/z* 198, 62%) and 9-fluorenyl$^+$ (*m/z* 165, 64%). The base peak, *m/z* 123, is probably $C_9H_{15}^+$ as fragment of the tetramethylcyclohexane residue.

Thus, the cycloreversion of **10** provided N_2 and the tetrasubstituted thiocarbonyl ylide **11**, which entered the usual electrocyclization. In kinetic measurements, the N_2 evolution at 50°C obeyed the first-order law only up to 69–74% reaction with half-lives of 76 min in xylene and 113 min in nitrobenzene. A modest negative influence of solvent polarity has been observed for the N_2 elimination of many 2,5-dihydro-1,3,4-thiadiazoles [5].

The reaction solution after N_2 extrusion contained a side-product: the occurrence of thiobenzophenone (**12**, 7%) suggested a concomitant cycloreversion to **12** and 2,2,6,6-tetramethyldiazocyclohexane (**13**). When the thermolysis of **10** (toluene, 50°C, 19 h) was carried out in the presence of 2,2,4,4-tetramethyl-3-thioxocyclobutanone (**14**, 1.1 equivalent), the yield of thiobenzophenone, spectrophotometrically determined, was 46%; the N_2 evolution was reduced to 51%. Thione **14** intercepted the (not isolated) diazoalkane **13**, and the new dispirodihydrothiadiazole **15** as a cycloaddition product was isolated. Analyses and NMR spectra were in accordance with structure **15**. The ^{13}C singlet at δ 219.3 for C=O demonstrates the intact cyclobutanone ring which—in the mass spectrum—is responsible for the loss of dimethylketene (*m/z* 252, 81%); the occurrence of **14**$^+$ (*m/z* 156, 15%) suggests some cycloreversion, and $C_9H_{15}^+$ (*m/z* 123, 65%) comes from the tetramethylcyclohexane ring.

The ^{1}H NMR analysis of the interception experiment (toluene, 50°C) denoted that two cycloreversion processes, *b* and *c* in Scheme 2, participated in the ratio 52:48; more precisely, 45% of thiirane **9** and 42% of **15** were found.

At room temperature, the cycloreversions of **10** are slow but clean. The reaction in benzene in the presence of 1.1 equivalent of **14** was monitored by ^{1}H NMR; after 14 days **10** was consumed, and a 39:61 ratio of thiirane **9** and interception product **15** was observed. An experiment in toluene at 4°C with 10 equivalents of **14** was run for 4 months, and

the product ratio was shifted further toward **15** (for analytical difficulties, see the Experimental).

The complex kinetic system of Scheme 2 can be described by two extremes. In the first, the equilibrium **10** ⇄ **12** + **13** is rapidly established and the interception by **14** is slow; here, the product ratio **9**/**15** should move toward **15** with increasing concentration of the intercepting thione **14**. The second extreme is characterized by an irreversible cycloreversion *c* (i.e., $k_{-c} = 0$), and **9**/**15** = k_b/k_c should be independent of the excess concentration of **14**. The following arguments speak for the first alternative with some correction toward an intermediate rate situation.

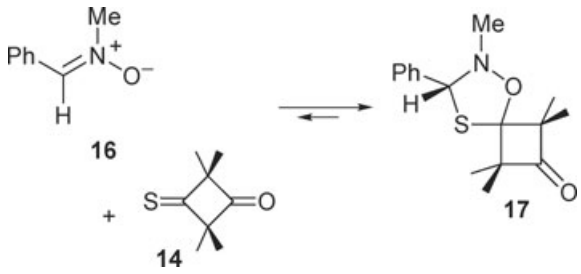
1. The presence of thione **14** decreases the N_2 volume and the yield of thiirane **9**. The growing amount of thiobenzophenone (**12**) indicates that the diazocyclohexane **13** is withdrawn from an equilibrium by capturing with **14**.

2. Thiobenzophenone (**12**) and the intercepting thione **14**—with rate constants k_{-c} and k_d in Scheme 2—compete for tetramethyldiazocyclohexane (**13**). With k_d [**14**] ≥ k_{-c}[**12**], the experimental ratio, **9**/**15** = 39:61 (benzene, room temp.), should correspond to k_b/k_c, the rate constants of the two cycloreversions. The conversion of **10** to **12** + **13** is rate determining, and **14** has at the beginning the advantage of a higher concentration (1.1 equivalents with respect to **10**) in the competition for **13**; the concentration of thiobenzophenone would build up and reach [**12**] = [**14**] = 0.55 equivalent after 90% reaction. However, a high ratio k_d/k_{-c} is inherently improbable, since **12** is 2.2 times more reactive than **14** in the cycloaddition with diphenyldiazomethane (**8**) [1].

3. If the reaction **12** + **13** → **10** is not completely suppressed, the product ratio **9**/**15** should respond to an increase of (**14**). In the experiment with 10 equivalents of **14**, the percentage of **15** in the product was increased and that of **9** dropped from 39% to about 30–33% (analytical difficulties were mentioned). The data still do not provide a definitive value of k_b/k_c.

4. Why is the cycloaddition **12** + **13** ⇄ **10** reversible whereas **13** + **14** → **15** is irreversible under the reaction conditions? In contrast to the cycloaliphatic thione **14**, thiobenzophenone (**1**) loses conjugation energy in the cycloaddition. A related case: In the reaction with *N*-methyl-*C*-phenylnitrone (**16**), thione **14** furnished the cycloadduct **17** which, in solution, shows a minor dissociation to the reactants. Due to unfavorable equilibria, thiobenzophenone and fluorene-9-thione do not react with nitrone **16** (Scheme 3) [6,7].

5. In the reaction without the intercepting thione **14**, the blue color reveals thiobenzophenone. Supposedly, some thermal decomposition of diazoalkane **13** at 50°C left an equivalent amount of **12** uncombined.

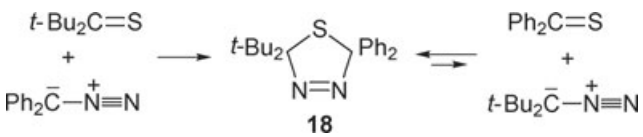


SCHEME 3

6. It is an open question whether the cycloaddition **7** + **8** is likewise reversible under the reaction conditions; path *a* (with k_{-a}) would be the third cycloreversion mode of **10** (Scheme 2). The two pairs, **7** + **8** and **12** + **13**, probably differ in the energies of ground state and TS.

A precedent to **10** is the dihydrothiadiazole **18** which Barton et al. prepared from two reactant pairs in the synthetic context of very hindered olefins by two-fold extrusion (Scheme 4) [8]. Despite phenyl substitution, **18** was isolated and eliminated N_2 in refluxing THF.

That brings us back to the original observation of the exceptional stability of **10** among the cycloadducts of diphenyldiazomethane which lose N_2 rapidly [1]. What is the rate ratio for the formation of **10** and its N_2 extrusion ? Dihydrothiadiazole **4** eliminates N_2 in xylene at 50°C 3.1 times faster than at 40°C [9]. Assuming the same temperature factor for the cycloreversion *b* of **10**, measured at 50°C in xylene, $k_b = 4.7 \times 10^{-5} s^{-1}$ comes out for 40°C (Scheme 2). The rate constant for the cycloaddition **7** + **8** → **10** at 40°C in DMF (0.579 L $mol^{-1}s^{-1}$, [1]) is calculated for the less polar $CHCl_3$, and the resulting $k_a = 0.230$ L $mol^{-1}s^{-1}$ is ≈4900 times faster than the N_2 extrusion of **10**. In contrast, even for the lower homolog, **6B** in Scheme 5, the rate constant of N_2 elimination exceeds that of formation by far.



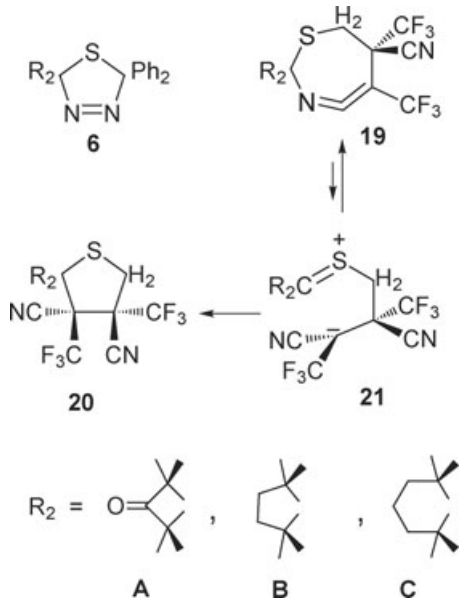
SCHEME 4

STERIC HINDRANCE TO THE ELIMINATION OF N_2

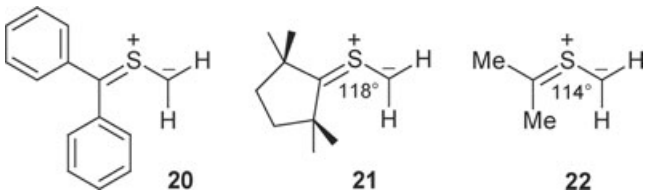
Various observations in the chemistry of thiocarbonyl ylides **2** point to increasing steric hindrance by R_2 = tetramethylcycloalkyl in the sequence **A** < **B** < **C** (Scheme 5). The TS of N_2 elimination of dihydrothiadiazoles **6** may be more closely related to the starting material than to the product, the thiocarbonyl ylide. The unusual stability of **10** is aptly ascribed to the steric hindrance of N_2 extrusion and—to a minor degree—to the bulk effect of substituents in **11**. The hindrance pertains to the rotations and distortions which are required in the course of the 1,3-dipolar cycloreversion.

A related stabilizing effect of the tetramethylcyclohexane residue was observed in the spirocyclic ketene imine **19C** (Scheme 5). The first-order isomerization of **19A** affording thiolane **20** via **21** has a half-reaction time of 8.7 h at 60°C [10] versus 38.5 h at 80°C for **19C** (both in C_6D_6) [11]; **19B** is even more labile than **19A** [12].

Calculations (B3LYP/6-31G*) of thiobenzophenone *S*-methylide (**20**) show that the endo-phenyl is twisted by 44° versus the CSC plane; the exo-phenyl with the smaller dihedral angle (35°) interacts somewhat more favorably with the allylanionic π system [13]. Compared with **20**, the tetramethylcyclohexane residue in **11** will increase the dihedral angles of phenyl, endo-Ph > exo-Ph, but phenyl conjugation still lowers the TS in the formation of **11**. That is demonstrated by the stability of dihydrothiadiazole



SCHEME 5



SCHEME 6

15, the interception product, which is more stable than **10**. It is worth mentioning that calculations of thiocarbonyl ylide **21** reveal C_s symmetry in the most stable conformation. The strain created by the bulky tetramethylcyclopentane ring is reflected in the angle CSC which is widened from 114° in **22** [4] to 118° in **21** [14] (see Scheme 6).

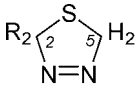
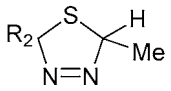
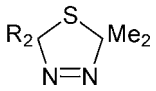
A final consideration discloses the stabilizing effect of methyl as third and fourth substituents in the dihydrothiadiazoles **1**, **23**, and **24** (Table 1). The methyl group as third substituent in **23** has only a moderate influence on the first-order rate constant of cycloreversion in the three model systems with R_2 = **A**, **D**, **B**; this methyl can dodge and will wind up as exo-methyl in the thiocarbonyl ylide. However, the 5,5-dimethyl derivatives **24** show lower rate constants of N_2 extrusion by factors of 7.2, 48, and 316, respectively. Thus, it is the fourth substituent that creates the extra strain in the TS of N_2 elimination, increasing in the sequence **A** < **D** < **B**.

EXPERIMENTAL

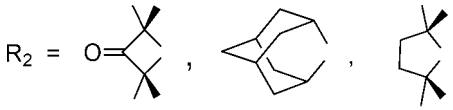
General [1]

*2,2,6,6-Tetramethylcyclohexanethione (**7**) and Diphenyldiazomethane (**8**). 6,6,10,10-Tetramethyl-3,3-diphenyl-4-thia-1,2-diazaspiro[4.5]dec-1-ene* (**10**). When the solutions of **7** (850 mg, 4.99 mmol) [7,15] and **8** (970 mg, 4.99 mmol), each in diethyl ether (5 mL), were combined at room temperature with stirring, the precipitation of colorless needles began after few seconds without liberation of N_2. After 1 h, filtering and washing with ether furnishes **10** (1.21 g, 66%), mp 129°C (gas evolution). IR (KBr) ν 693 m, 698 st, 746 m, 759 m (arom. out-of-plane deform.), 971 st, 1380 m, 1388 m; 1447 st, 1489 m, 1555 w, 1595 w (arom. ring vibr., N=N). ^{1}H NMR (C_6D_6, 80 MHz) δ 0.44, 1.13 (2 s, 4 Me), 1.23–2.30 (m, $3CH_2$), 6.78–7.15 (m, 6 arom. H), 7.56–7.80 (m, 4 arom. H); ($CDCl_3$) δ 0.30 (s, 2 × 2Me), 1.19 (s, 2 × 2Me), 1.38–2.10 (m, 6H), 6.94–7.35 (m, 6 arom. H), 7.43–7.68 (m, 4 arom. H). Anal. Calcd for $C_{23}H_{28}N_2S$ (364.54): C, 75.78; H, 7.74; N, 7.69; S, 8.80; found: C, 76.08; H, 7.71; N, 7.87; S, 8.82.

TABLE 1 Cycloreversion of Dihydrothiadiazoles in Xylene; Kinetics of N_2 Evolution Rate Constants $10^4 k_1[s^{-1}]$

R_2	Temp. (°C)	**1**	**23**	**24**	k_1/k_{24}
A	50	6.80	6.06	0.95	7.2
D	50	4.50	3.09	0.093	48
B	50	3.16	3.57		
B	100	398		1.26	316



A **D** **B**

*4,4,8,8- Tetramethyl-2,2-diphenyl-1-thiaspiro[2.5]-octane (**9**).* (a) Thiadiazoline **10** (510 mg, 1.40 mmol) was heated in benzene (10 mL) at 50°C for 24 h. The solution turned blue, and spectrophotometry at 604 nm after some hours indicated thiobenzophenone (**12**, 92 μmol, 7%). Evaporation of the solvent and recrystallization from methanol afforded **9** (0.20 g, 42%) as colorless needles, mp 191–192°C. IR (KBr) ν 694 m, 709 st, 747 m , 783 w, 1366 m, 1382 m, 1444 st, 1457 m, 1485 m, 1596 w. ^{1}H NMR (C_6D_6, 200 MHz) δ 0.45, 1.46 (2 s, 4Me), 1.0–1.8 (m, $3CH_2$), 6.93–7.03 (m, 6 arom. H), 7.38–7.80 (m, 4 arom. H); ($CDCl_3$) δ 0.24, 1.55 (2 s, 4Me), 1.12–1.84 (m, $3CH_2$), 6.93–7.80 (m, 10 arom. H). ^{13}C NMR ($CDCl_3$, 20.2 MHz) δ19.2 (t, C-6), 27.0, 33.8 (2 q, 4Me), 40.1 (s, C-4, C-8), 45.0 (t, C-5, C-7), 70.8 (s, C-3), 75.5 (s, C-2), 126.2, 126.8, 128.5, 128.8, 130.3 (5d, 5 × 2 arom. CH), 145.5 (s, 2 arom. C_q). MS (EI, 70 eV), *m/z* (%) 336 (45) [M^+], 321 (6) [M^+–Me], 304 (5) [M^+–S], 293 (4) [M^+–C_3H_7], 251 (84) [293^+–C_3H_6], 219 (22) [251^+–S], 211 (32), 198 (62) [$C_{13}H_{10}S^+$, **12**$^+$], 165 (64) [$C_{13}H_9^+$, fluorenyl$^+$], 123 (100) [$C_9H_{15}^+$, ^{13}C Calcd 10.0/found 9.6], 91 (27) [$C_7H_7^+$], 81 (21), 77 (11) [Ph^+]. Anal. Calcd for $C_{23}H_{28}S$ (336.52): C, 82.08; H, 8.39; S, 9.53; found: C, 82.19; H, 8.40; S, 9.52.

(b) *Quantitat. ^{1}H NMR analysis.* Thiadiazoline **10** (0.76 mmol) in C_6D_6 (0.5 mL) was heated in an NMR tube at 50°C for 16 h. Comparison of the integrals at δ 0.45 with that of the weight standard (*as*-$C_2H_2Cl_4$) furnished 81% of **9**.

(c) *Kinetics of N_2 extrusion from* **10.** The N_2 evolution from the xylene solution at 50°C was measured volumetrically by a nitrometer. Evaluation of 28 volume readings up to 72% by $kt = \log (V_\infty)/(V_\infty - V_t)$ furnished $k_1 = 1.46 \times 10^{-4}$ s^{-1} with $r^2 = 0.9992$; a second run gave $k_1 = 1.60 \times 10^{-4}$ s^{-1}. Two experiments in nitrobenzene at 50°C provided $10^4 k_1 = 1.01$ and 1.04 s^{-1} with $r^2 = 0.9986$. Above 69–74% reaction, systematic deviations from the first-order law were observed.

*Interception of 2,2,6,6-Tetramethyldiazocyclohexane (**13**)*

*1,1,3,3,7,7,11,11-Octamethyl-5 -thia-12,13-diazadispiro[3.1.5.2]tridecane-2-one (**15**).* Thiadiazoline **10** (500 mg, 1.37 mmol) and 2,2,4,4-tetramethyl-3-thioxocyclobutanone (**14**, 237 mg, 1.52 mmol) [16] in abs. benzene (5.5 mL) were stirred at room temperature for 11 days. By CC (silica gel) with pentane, thiirane **9** (0.20 g, 43%) was eluted, followed by **15** (130 mg, 29%) eluted with pentane/CH_2Cl_2. Recrystallized from pentane, the colorless **15** showed mp 165–166°C (−N_2). IR (KBr) ν 980 w, 1024 m, 1379 m, 1447 m, 1470 m, 1480 m, 1577 w; 1792 st (C=O). ^{1}H NMR (C_6D_6, 80 MHz) δ 0.48, 1.13, 1.18, 1.26 (4 s, 8Me), 1.1–2.4 (m, 3 CH_2); ($CDCl_3$) δ 0.53, 1.24, 1.28, 1.32 (4 s, 8 Me), 1.45–2.21 (m, $3CH_2$). ^{13}C NMR ($CDCl_3$, 20.2 MHz) δ 18.9 (t, C-9), 19.4, 23.6, 27.6, 29.3 (4 q, 4 × 2Me), 38.8 (t, C-8/C-10), 41.0 (s, C-7/C-11), 67.2 (s, C-1/C-3), 111.1, 127.9 (2s, C-4, C-6), 219.3 (s, C=O). MS (70 eV, 60°C), *m/z* (%) 322 (16) [M^+], 307 (1) [M^+–Me], 294 (2) [M^+–N_2], 279 (6) [M^+–N_2–Me], 252 (81) [M^+–Me_2C=C=O], 238 (18), 224 (21) [252^+–N_2], 209 (8) [224^+–Me], 192 (4) [224^+–S], 170 (8), 156 (15) [**14**$^+$], 137 (11) [$C_{10}H_{17}^+$], 123 (65) [$C_9H_{15}^+$], 109 (14) [$C_8H_{13}^+$], 95 (40) [$C_7H_{11}^+$], 86 (53) [Me_2C=C=S^+], 81 (60) [$C_6H_9^+$], 69 (50) [$C_5H_9^+$], 55 (40) [$C_4H_7^+$], 41 (100) [$C_3H_5^+$]. Anal. Calcd for $C_{18}H_{30}N_2OS$ (322.50): C, 67.03; H, 9.38; N, 8.69; S, 9.94; found: C, 67.14; H, 9.25; N, 8.89; S, 10.00.

Analysis of Competing Cycloreversions of **10**. (a) *Toluene, 50°C.* The suspension of **10** (365 mg,

1.00 mmol) in toluene (5 mL) was stirred with thione **14** (172 mg, 1.10 mmol) under argon in a 50°C-bath for 19 h. The spectrophotometric analysis of thiobenzophenone (**12**) at λ_{max} 604 nm ($\varepsilon = 210$) gave 0.455 mmol (46%). Addition of **8** (88.0 mg, 0.453 mmol) removed **12** by conversion to tetraphenyl-thiirane [1]. The residual thione **14** was responsible for the now red color of the solution. The extinction of the isolated absorption band at λ_{max} 528 ($\varepsilon = 13.2$) indicated 0.45 mmol of **14** (consumption of **14**: 0.65 mmol).

(b) *Toluene, 50°C.* When the reaction of **10** (1.00 mmol, 0.19 M) and **14** (0.21 M) was repeated with a gas burette connected, the N_2 volume was 51% after 19 h at 50°C. Quantitative ^{1}H NMR analysis (*sym*-$C_2H_2Cl_4$) in $CDCl_3$ disclosed thiirane **9** (45%, s at δ 0.24) and thiadiazoline **15** (42%, s at 0.53); **9**/**15** = 52:48. There are no unassigned Me singlets in the spectrum.

(c) *Benzene, room temperature.* The suspension of **10** (0.250 mmol, ≈0.24 M solution) and **14** (0.275 mmol, ≈0.27 M), in C_6D_6 (1.0 mL) was stirred, and **10** dissolved in several hours. The reaction progress was monitored by ^{1}H NMR (δ 0.42 for **10** + **9**, 1.47 for **9**, 0.48 and 1.13 for **15**, 1.05 for **14**); after 17 h, 23% of **10** was still present. The signals of **10** had disappeared after 14 days, and **9**/**15** = 39:61 was observed; no unassigned Me singlets. The ratio did not change in further 21 days.

(d) *Toluene, 4°C.* The suspension of **10** (222 mg, 0.61 mmol) and thione **14** (926 mg, 5.93 mmol) in toluene (5 mL) was kept in a closed flask at 4°C for 4 months (shaking now and then until solution was homogenous); the concentrations were ≈0.11 M in **10** and 1.02 M in **14**. After evaporation of the solvent, the excess of **14** was removed in high vacuum. The ^{1}H NMR analysis in $CDCl_3$ (signals as above) displayed **9**/**15** = 41:59, but unassigned methyl singlets (δ1.37, 1.47; about 25% of the used **10**) raised doubts; probably some loss of N_2 from **15** occurred when the excess of **14** was distilled off at high vacuum.

(e) *Acetonitrile, 4°C.* Analogous reaction of **10** (272 mg, 0.599 mmol, 0.10 M solution) and **14** (928 mg, 5.95 mmol, 1.03 M solution) in acetonitrile (5 mL) for 4 months. Work-up and ^{1}H NMR analysis ($CDCl_3$) furnished **10**/**9**/**15** = 52:21:26. Again, additional Me singlets occur at δ1.36, 1.45 and smaller ones at 1.38, 1.41. Therefore, we do not fully trust the observed **9**/**15** = 45:55; the amount of **15** is probably higher. In contrast to the experiment in toluene, 52% of **10** was still unconsumed after 4 months. The negative effect of solvent polarity on the rate of N_2 elimination, observed for several dihydrothiadiazoles [5], is not large enough to explain the big difference in reaction progress; probably the low solubility of **10** in acetonitrile is responsible.

ACKNOWLEDGMENTS

We thank cand. chem. Ulrich Pohl for initial experiments, and the Fonds der Chemischen Industrie, Frankfurt, for support. Helmut Huber helped in the recording of the NMR spectra, and Reinhard Seidl contributed the mass spectra. Helmut Schulz and Magdalena Schwarz carried out the elemental analyses. They all deserve our thanks.

REFERENCES

[1] Huisgen, R.; Langhals, E.; Pohl, U. Heteroatom Chem 2006, 17, 433–442.
[2] Giera, H.; Huisgen, R.; Langhals, E.; Polborn, K. Helv Chim Acta 2002, 85, 1523–1545.
[3] Huisgen, R.; Kalvinsch, I.; Li, X.; Mloston, G. Eur J Org Chem 2000, 1685–1694.
[4] Sustmann, R.; Sicking, W.; Huisgen, R. Chem Eur J 2003, 2245–2255.
[5] Huisgen, R.; Langhals, E.; Mloston, G.; Oshima, T.; Rapp, J. J Het Chem 1987, 24, S1–S11.
[6] Black, D. S. C.; Watson, K. G. Aust J Chem 1973, 26, 2491–2504.
[7] Huisgen, R.; Fisera, L.; Giera, H.; Sustmann, R. J Am Chem Soc 1995, 117, 9671–9678.
[8] Barton, D. H. R.; Gusiec jun., C. S.; Shahak, I. J Chem Soc, Perkin Trans I 1974, 1794–1799.
[9] Giera, H.; Huisgen, R.; Langhals, E.; Polborn, K. Helv Chim Acta 2002, 85, 1523–1545.
[10] Huisgen, R.; Mloston, G.; Langhals, E.; Oshima, T. Helv Chim Acta 2002, 85, 2668–2685.
[11] Huisgen, R.; Giera, H.; Polborn, K. Tetrahedron 2005, 61, 6143–6153.
[12] Huisgen, R.; Langhals, E.; Polborn, K.; Kharagiosoff, K. Helv Chim Acta 2004, 87, 1426–1445.
[13] Sustmann, R.; Sicking, W.; Huisgen, R. J Am Chem Soc 2003, 125, 14425–14434.
[14] Sustmann, R.; Sicking, W.; Huisgen, R. Eur J Org Chem 2005, 1505–1518.
[15] Klages, C.-P.; Voss, J. J Chem Res 1977, S156, M1831.
[16] Elam, E. U.; Davis, H. E. J Org Chem 1967, 32, 1562–1565.