δ 134.4 (Ar), 132.5 (Ar), 123.7 (Ar), 119.0 (Ar), 118.6 (Ar), 118.3 (Ar), 117.8 (Ar), 117.6 (Ar), 116.9 (Ar), 116.8 (Ar), 116.3 (Ar), 116.1 (Ar), 42.6 (C of tBu), 41.3 (CH_2), 40.5 (CH_3 of t-Bu).

2,6-Bishydroxymethyl-4-phenylphenol 6. This compound was isolated from chloroform solution after removal of **3** as a chloroform-insoluble material from the reaction product mixture. The chloroform solution was concentrated to 100 mL, added 50 mL of hexane, and then stood overnight at room temperature. The precipitate was collected by filtration, washed with hexane and dried over $MgSO_4$. Recrystallization from water afforded 7.29 g (35%) of the desired product as needles; mp. 116-117℃ ; IR (KBr) 3360 (OH), 873 cm^{-1} (1,2,3,5-tetrasubstituted Ar); ^{1}H-NMR (acetone-d_6) δ 7.78-7.18 (m, 7, ArH), 4.80 (s, 4 CH_2), 4.10 (br, 3, OH).

2-[3-(5-*tert*-Butylsalicyl)-5-phenylsalicyl]-4-*tert*-butylphenol 7. A solution of 60.0 g (400 mmole) of *p-tert*-butylphenol and 130 mg of *p*-TsOH in 200 mL of benzene was refluxed. A total of 10.0 g (43.5 mmole) of **6** was added in portions over a period of 8 h, and the reflux was extended overnight. After removing the excess *p-tert*-butylphenol by steam distillation, the residue was collected by filtration, washed with water and dried over $MgSO_4$. Recrystallization of the crude product from hexane afforded 20.2 g (94%) of a colorless crystalline **7**; mp. 204-206℃ ; IR (KBr) 3290 cm^{-1} (OH); ^{1}H-NMR ($CDCl_3$) δ 8.66 (br, 3, OH), 7.47-6.76 (m, 13, ArH), 4.00 (s, 4, CH_2), 1.30 (s, 18, tBu).

2,6-Bis bromopmethyl-4-phenylphenol 8. A solution of 3.20 g (14 mmole) of **6** and 7 mL of conc HBr in 100 mL of benzene was refluxed for 19 h with removing the water by Dean Stark trap. The reaction was quenched with 6 N NaOH and the organic layer was separated, washed successively with 10% HCl, water and brine, and dried over $MgSO_4$. The residue obtained by evaporation of solvent was recrystallized twice from chloroform and hexane to yield 3.35 g (67%) of **8** as a colorless powder; mp. 125-127℃ ; IR (KBr) 3400 cm^{-1} (OH); ^{1}H-NMR ($CDCl_3$) δ 7.70-7.50 (m, 7, ArH), 5.70 (s, 1, OH), 4.60 (s, 4, CH_2).

5,17-Di-*tert*-butyl-11,23-diphenyl-25,26,27,28-tetrahydroxycalix[4]arene 2. In a 1-L three neck round-bottomed flask equipped with condenser, dropping funnel and stirrer a mixture of 150 mL of dried dioxane and 1.7 mL (15.5 mmole) of $TiCl_4$ was refluxed under nitrogen. A solution of 1.20 g (3.5 mmole) of **8** and 1.87 g (3.7 mmole) of **7** in 300 mL of dioxane was added during 6 h. After refluxing was continued for 53 h, the reaction mixture was worked up as the same method as compound **1** and afforded 0.60 g (25%) of colorless crystalline **2**; mp; >360℃ ; IR (KBr) 3200 cm^{-1} (OH); ^{1}H-NMR ($CDCl_3$) δ 10.38 (s, 4, OH), 7.38-7.24 (m, 18, ArH), 4.30 (d, 4, CH_2), 3.60 (d, 4, CH_2), 1.22 (s, 18, t-Bu); ^{13}C-NMR ($CDCl_3$) δ 149.00 (Ar), 147.23 (Ar), 145.39 (Ar), 141.60 (Ar), 136.02 (Ar), 129.09 (Ar), 129.03 (Ar), 128.38 (Ar), 127.99 (Ar), 127.39 (Ar), 127.09 (Ar), 126.49 (Ar), 34.25 (CH_2), 32.52 (C of tBu), 31.63 (CH_3 of tBu).

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A Convenient Synthesis of 2-methyl-8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo [4,3-a] pyrazines

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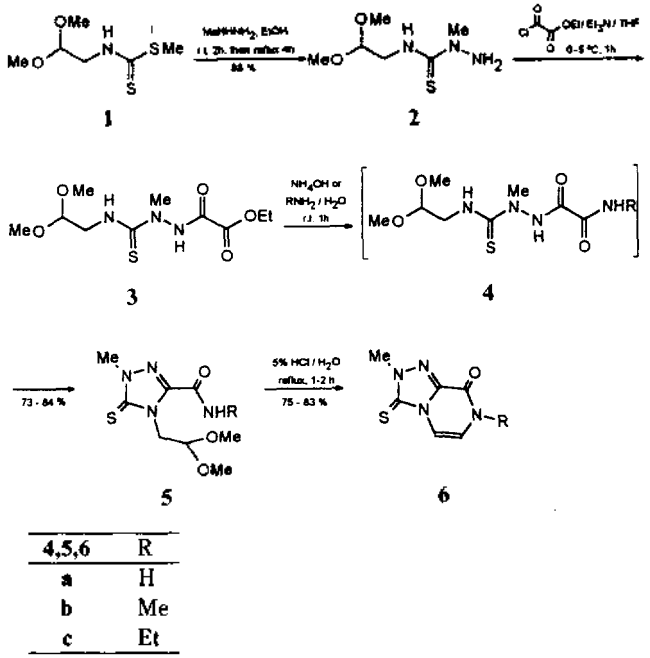
As part of an investigation on the synthesis of cephalosporin antibiotics[1,2], we needed various heterocyclic thiols, in particular, of bridgehead-nitrogen heterocycles containing the 1,2,4-triazole moiety, and we recently reported[3] the novel synthesis of 8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo[4,3-a]pyrazines. We now describe a general method for the preparation of hitherto unknown 2-methyl derivatives **6** based on the simple annulation of the pyrazinone ring onto the triazole ring precursor **5** followed by the previously reported method[3].

The reaction of methyl *N*-(2,2-dimethoxyethyl)dithiocarbamate (**1**) with methylhydrazine was carried out in ethanol at reflux temperature and gave a regioselective product, 4-(2,2-dimethoxyethyl)-2-methylthiosemicarbazide (**2**) in good yield (88%). The reaction of 2-methylthiosemicarbazide **2** with ethyl oxalyl chloride in the presence of triethylamine in tetrahydrofuran afforded 1-ethoxyoxalyl-2-methylthiosemicarbazide **3**, which was used in the next step without purification. Interestingly the reaction of **3** with excess ammonia or primary amines in water at room temperature gave cycli-



4,5,6	R
a	H
b	Me
c	Et

Scheme 1.

zation products, 1-methyl-5-thioxo-4,5-dihydro-1,2,4-triazoles **5** directly presumably *via* **4**. Finally intramolecular condensation reaction of **5** bearing acetal and aminocarbonyl moieties with 5% hydrochloric acid at reflux temperature gave the desired 2-methyl-8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo[4,3-a]pyrazines (**6**) in high yields.

Experimental Section

The NMR spectra were recorded on a Bruker AM 200 spectrometer using tetramethylsilane as internal standard. Melting points were taken using a Electrothermal melting point apparatus and are uncorrected. Methylhydrazine, ethyl oxalyl chloride, Et_3N, $MeNH_2$ (40 wt% solution in water), and $EtNH_2$ (70 wt% solution in water) were purchased from Aldrich Chemical Co.

4-(2,2-Dimethoxyethyl)-2-methylthiosemicarbazide (2). To a stirred solution of methyl-*N*-(2,2-dimethoxyethyl) dithiocarbamate (**1**; 19.5 g, 100 mmol) in EtOH (150 mL) is added $MeNHNH_2$ (4.60 g, 100 mmol). The mixture is stirred at r.t. for 2 h and heated at reflux temperature for 4 h, then concentrated under reduced pressure. The residual crystalline solid is separated by filtration using Et_2O to give **2** as colorless crystals; yield 17.0 g (88%); mp. 93-94℃; ^{1}H-NMR (DMSO-d_6) δ 3.33 (s, 6H, OCH_3), 3.49 (s, 3H, NCH_3), 3.60 (t, 2H, J=5 Hz, CH_2), 4.57 (t, 1H, J=5 Hz, CH), 5.20 (br s, 2H, NH_2), 8.17 (t, 1H, J=5.5 Hz, NH).

3-Carbamoyl-4-(2,2-dimethoxyethyl)-1-methyl-5-thioxo-4,5-dihydro-1,2,4-triazole (5a). To a stirred solution of 2-methylthiocarbazide (**2**, 19.3 g, 100 mmol) in THF (150 mL) is added Et_3N (11.1 g, 110 mmol) and EtO_2CCOCl (14.3 g, 105 mmol) in a dropwise manner at 0-5℃. After stirring for 1 h at ambient temperature, the precipitated solid ($Et_3N\cdot HCl$) is filtered off, and the filtrate is concentrated under reduced pressure. The residual material **3** is dissolved in water (150 mL) and 30% aq. NH_4OH (32.1 g, 300 mmol) is added to the above solution. The reaction mixture is stirred at r.t. for 1 h. After cooling, the precipitated solid, which is gradually separated during the reaction, is filtered off, and recrystallized from the water to give **5a** as colorless crystals; yield: 20.6 g (84%); mp. 159-160℃; ^{1}H-NMR (DMSO-d_6) δ 3.32 (s, 6H, OCH_3), 3.80 (s, 3H, NCH_3), 4.55 (d, 2H, J=5 Hz, CH_2), 4.77 (t, 1H, J=5 Hz, CH), 8.07 and 8.36 (s, 1H each, NH_2).

3-*N*-Methylcarbamoyl-4-(2,2-dimethoxyethyl)-1-methyl-5-thioxo-4,5-dihydro-1,2,4-triazole (5b). With the same procedure for the preparation of **5a**, compound **5b** is obtained by the treatment of 40% aq. $MeNH_2$ (23.2 g, 300 mmol) and recrystallized from the water: yield 20.5 g (79%); mp. 121-122℃; ^{1}H-NMR (DMSO-d_6) δ 2.78 (d, 3H, J=4 Hz, $NHCH_3$), 3.28 (s, 6H, OCH_3), 3.76 (s, 3H, NCH_3), 4.51 (d, 2H, J=5 Hz, CH_2), 4.75 (t, 1H, J=5 Hz, CH), 8.93 (br s, 1H, NH).

3-*N*-Ethylcarbamoyl-4-(2,2-dimethoxyethyl)-1-methyl-5-thioxo-4,5-dihydro-1,2,4-triazole (5c). With the same procedure for the preparation of **5a**, compound **5c** is obtained by the treatment of 70 wt% aq. $EtNH_2$ (19.3 g, 300 mmol) and separated from the reaction mixture by column chromatography[4] on silica gel (hexane/EtOAc; 2 : 1): yield 18.8 g (69%); mp. 91-92℃; ^{1}H-NMR (DMSO-d_6), δ 1.06 (t, 3H, J=7 Hz, CH_3), 3.16 (m, 2H, NCH_2), 3.26 (s, 6H, OCH_3), 3.75 (s, 3H, NCH_3), 4.46 (d, 2H, J=5 Hz, CH_2), 4.67 (t, 1H, J=5 Hz, CH), 8.73 (br s, 1H, NH).

2-Methyl-8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo[4,3-a]pyrazine (6a). To a stirred suspension of 3-carbamoyltriazole (**5a**, 2.46 g, 10 mmol) in water (20 mL) is added 5% HCl (22.0 mL, 30 mmol). The reaction mixture is stirred at reflux temperature for 1 h. After cooling, the precipitated solid is filtered off, washed with cold water (5 mL), and dried to give **6a** as colorless crystals; yield 1.92 g (78%); mp>275℃; ^{1}H-NMR (DMSO-d_6) δ 3.85 (s, 3H, NCH_3), 6.90 (d, 1H, J=6 Hz, H-6), 7.17 (d, 1H, J=6 Hz, H-5), 11.42 (br s, 1H, NH).

2,7-Dimethyl-8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo[4,3-a]pyrazine (6b). With the same procedure for the preparation of **6a**, compound **6b** is obtained from the reaction of 3-*N*-methylcarbamoyltriazole (**5b**, 2.60 g, 10 mmol) with 5% HCl (22.0 mL, 30 mmol) for 2 h; yield 1.63 g (83%); mp. 268-270℃; ^{1}H-NMR (DMSO-d_6) δ 3.44 (s, 3H, $CONCH_3$), 3.90 (s, 3H, $CSNCH_3$), 7.21 (d, 1H, J=6 Hz, H-6), 7.35 (d, 1H, J=6 Hz, H-5).

7-Ethyl-2-methyl-8-oxo-3-thioxo-2,3,7,8-tetrahydro-1,2,4-triazolo[4,3-a]pyrazine (6c). With the same procedure for the preparation of **6a**, compound **6c** is obtained from the reaction of 3-*N*-ethylcarbamoyltriazole (**5c**, 2.74 g, 10 mmol) with 5% HCl (22.0 mL, 30 mmol) for 2 h; yield 1.58 g (75%); mp. 274-275℃ (dec.); ^{1}H-NMR (DMSO-d_6) δ 1.23 (t, 3H, J=7 Hz, CH_3), 3.87 (s, 3H, NCH_3), 3.91 (q, 2H, J=7 Hz, NCH_2), 7.21 (d, 1H, J=6 Hz, H-6), 7.25 (d, 1H, J=6 Hz, H-5).

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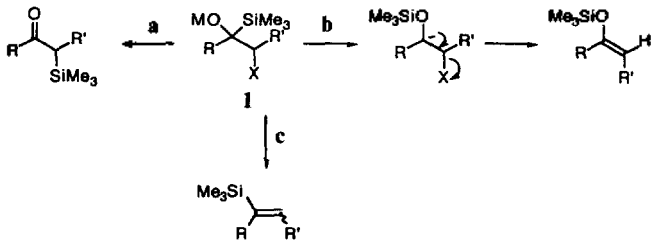
4. During the reaction compound **5c** is not precipitated out.



Scheme 1.

Reactions of Acylsilanes with Phenylthio(trimethylsilyl)methyllithium. A Competitive Peterson and Brook Rearrangement-Elimination Reactions in the β-Thiophenyl-α,β-disilylalkoxides

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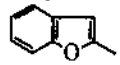
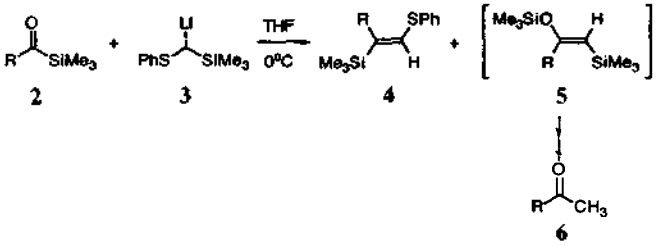
The intermediate α-trimethylsilyl-β-X-alkoxides **1** undergo different types of reactions depending on the nature of R and X groups. The intermediate **1** (X=Cl) formed in the reaction of (α-chloroacyl)silane with either Grignard reagents[1] or enolates[2] suffers silyl migration from C to C, giving β-ketoalkylsilane (path *a*, Scheme 1). The intermediate **1** with a suitable leaving group such as PhS, PhSO, $PhSO_2$, PhSe, CN, or OH affords silyl enol ether *via* Brook rearrangement-elimination sequence (path *b*).[3] The intermediate **1**(X=Ph_3P^+) generated from the reaction of acylsilanes with Wittig reagents undergoes alternative reactions depending on R group. When R is an alkyl group, only the Wittig product is formed (path *c*). On the other hand, if R is an aryl group silyl enol ether is produced through path *b*.[4] Thus, we examine α,β-disilylalkoxides with a phenylthio group (**1**, X=PhS, R'=$SiMe_3$) in order to distinguish among the existing competitive reaction pathways.

When phenylthio(trimethylsilyl)methyllithium (**3**)[5] prepared by the treatment of phenylthio(trimethylsilyl)methane with *n*-butyllithium in tetrahydrofuran (THF) reacted with acylsilanes **2** at 0℃, mixtues of (β-phenylthio)vinylsilanes **4** and methyl ketones **6** were produced after work-up and chromatography. All attempts to isolate silyl enol ethers **5** were failed. The results are shown in Table 1.

Table 1. Yields of **4** and **6**

Acylsilane **2**		Vinylsilane **4**		Ketone **6**
Compound	R	yield(%)*	isomeric purity of E**	yield(%)*
a	Ph	49	>99%	40
b	*p*-ClC_6H_4	47	>99%	51
c	*p*-BrC_6H_4	52	99%	47
d	*p*-$CH_3C_6H_4$	47	>99%	44
e	*p*-$CH_3OC_6H_4$	51	85%	25
f		42	98%	44
g		50	86%	36
h	$PhCH_2CH_2$	40	96%	21
i	$CH_3(CH_2)_9CH_2$	51	95%	24

*Isolated yields
**Determined by ^1H NMR and GC analysis



The structures of (β-phenylthio)vinylsilanes **4** were assigned by ^1H, ^{13}C and MS spectroscopy (Table 2). *E*-vinylsilanes were predominant over *Z*-isomers (>85%) in every cases

Table 2. Spectral Data of (β-phenylthio)vinylsilane **4**

Vinylsilane	^1H-NMR ($CDCl_3$) δ, *J* (Hz)	^{13}C-NMR ($CDCl_3$) δ	MS m/z (rel. intensity, %)
(E)-4a	0.12 (s, 9H), 6.76 (s, 1H), 7.08-7.41 (m, 10)	−1.43, 126.30, 126.80, 127.46, 128.42, 129.05, 129.97, 135.12, 136.27, 141.64, 144.13	284 (M^+, 9), 269 (1), 167 (13), 84 (12), 73 (100)
(E)-4b	0.11 (s, 9H), 6.76 (s, 1H), 7.00-7.40 (m, 9H)	−1.48, 124.59, 126.02, 127.00, 128.71, 128.89, 129.13, 130.08, 132.14, 135.88, 135.98, 140.04, 142.79	320 (M+2, 2), 318 (M^+, 6), 167 (12) 84 (8), 73 (100)