Ylide Reactions of Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides

Yoshiro Sato,* Yoko Yagi, and Masami Koto

Faculty of Pharmaceutical Sciences, Nagoya City University, Tanabe-dori, Mizuho-ku, Nagoya 467, Japan

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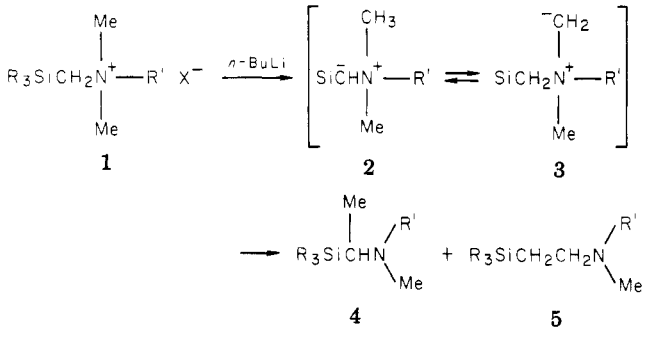
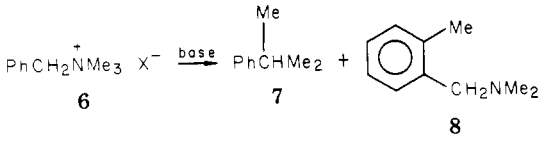
Deprotonation of benzyldimethyl[(triorganosilyl)methyl]ammonium halides (**10**) with sodium amide or *n*-butyllithium afforded silylated ylide intermediates **11**, which were rearranged into *N,N*-dimethyl-2-[(triorganosilyl)methyl]benzylamines (**13**) accompanied by the formation of Sommelet–Hauser and Stevens rearrangement products (**12** and **22**). The ylide formation by the cleavage of carbon–silicon bonds also is discussed in the reaction of **10** with sodium amide and lithium aluminum hydride.

Silicon exerts a pronounced stabilizing effect on ylide carbanions. Deprotonation of α-silylated phosphonium or sulfonium salts with organometallic bases occurs selectively to form ylides having the silicon substituents directly attached to the carbanions.[1] A similar stabilizing effect of silyl groups has been observed in the formation of ammonium ylide intermediates from α-silylated ammonium salts. When [(triorganosilyl)methyl]ammonium halides (**1**) were treated with *n*-butyllithium, the main products



were 1-(triorganosilyl)ethylamines (**4**), which should be the Stevens rearrangement products of silylated ylides **2**.[2,3]

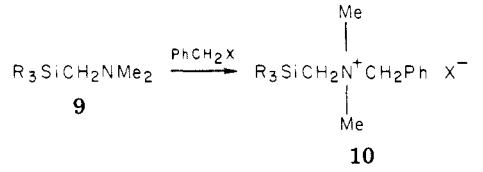
Sommelet–Hauser rearrangement as well as Stevens rearrangement is well-known in the base-promoting reactions of benzyltrimethylammonium salts (**6**).[4] A mixture



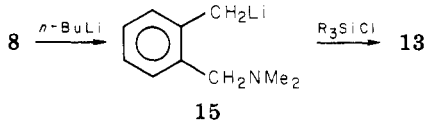
of a Stevens product (**7**) and a Sommelet–Hauser rearrangement product (**8**) is obtained when *n*-butyllithium is the base. However, only **8** is formed when sodium amide is employed in liquid ammonia. This paper reports the behavior of triorganosilyl groups in ylide intermediates generated from benzyldimethyl[(triorganosilyl)methyl]ammonium halides (**10**).

The starting compounds **10** were obtained by treatment of dimethylaminomethyltriorganosilanes (**9**) with benzyl halides (Table I).

The reaction of benzyldimethyl[(trimethylsilyl)methyl]ammonium bromide (**10a**) with sodium amide in liquid ammonia gave two ortho rearrangement products,



N,N-dimethyl-2-methyl-α-(trimethylsilyl)benzylamine (**12a**) and *N,N*-dimethyl-2-methylbenzylamine (**8**) (Scheme I). The former one should be a Sommelet–Hauser-type rearrangement product of a silylated ylide (**11a**). Similar treatment of **10b–d**, each having at least one phenyl substituent on the silicon, afforded the corresponding Sommelet–Hauser rearrangement products **12b–d** and their isomers **13b–d**, accompanied by **8**, respectively (Tables II–IV). ^{1}H NMR and mass spectral analyses of **13b–d** suggested their structures as *N,N*-dimethyl-2-[(triorganosilyl)methyl]benzylamines (Tables V and VII). Compound **13** can be easily synthesized by reaction of 2-[(dimethyl-



amino)methyl]benzyllithium (**15**) with triorganochlorosilanes.[5] Indeed, **13d** was identified with an authentic sample prepared by the independent route.

In all of the reaction mixtures, **8** was present, and its yield increased with an increase of phenyl substituent on the silicon. Acid treatment of **12d** easily gave a desilylated product, **8**, but **12a** was quite stable in a dilute acid solution. Further, careful workup of the reaction mixture did not bring about a significant change of the yields of **8**. Thus **8** is not a desilylated product of **12** but may be a rearrangement product of an ylide **14** produced by cleavage of the carbon–silicon bond of **10**. This possibility was demonstrated by the following experiment.

Treatment of 1,1,3,3-tetramethyl-1,2,3,4-tetrahydrobenzo[*d*]-1,3-azoniasiline iodine[6] (**16**) with sodium amide gave dimethyl[2-methyl-3-[(dimethylamino)methyl]-phenyl]silanol (**19**), which was identified with an authentic sample prepared from *N,N*-dimethyl-2-methyl-3-bromobenzylamine (**21**) via its Grignard reagent. The silanol **19** may be a hydrolysis product formed during the workup from aminosilane **18**, which is a Sommelet–Hauser rearrangement product of ylide **17**. Thus, **17** should be produced from **16** as a result of carbon–silicon bond cleavage by attack of an amide anion at the silicon.

When the deprotonation of **10** was carried out with *n*-butyllithium at 0 °C in THF, the main product was **13**,

(1) For a review of silyl ylides, see H. Schmidbaur, *Acc. Chem. Res.*, 8, 62 (1975).
(2) N. E. Miller, *Inorg. Chem.*, 4, 1458 (1965).
(3) Y. Sato, *Yuki Gosei Kagaku Kyokai Shi*, 36, 834 (1978).
(4) A. R. Lepley and A. G. Giumanini, *Mech. Mol. Migr.*, 3, 297 (1971); E. M. Kaiser and D. W. Slocum in "Organic Reactive Intermediates", S. P. McManus, Ed., Academic Press, New York, 1973, pp 381.
(5) C. T. Viswanathan and C. A. Wilkie, *J. Organomet. Chem.*, 54, 1 (1973).
(6) Y. Sato, Y. Fukami, and H. Shirai, *J. Organomet. Chem.*, 78, 75 (1974).

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Table I.
Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides (10)

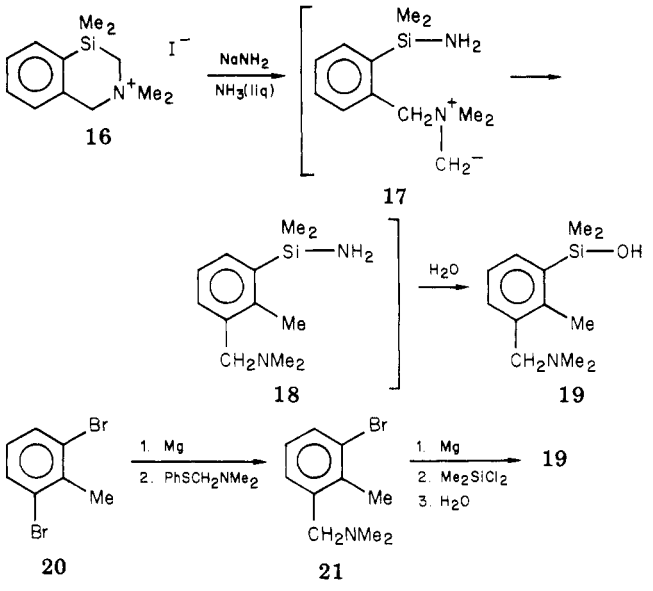
	R_3Si	X	yield, %	mp, °C	^{1}H NMR ($CDCl_3$), δ $SiCH_2$	$ArCH_2$
10a	Me_3Si	Br	85	196-197	3.50	5.15
10b	$PhMe_2Si$	Br	95	159-160	3.78	5.07
10c	Ph_2MeSi	Br	81	152-153	4.11	5.10
10d	Ph_3Si	Cl	87	232-235	4.40	5.16

Table II. Reaction of Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides (10) with Sodium Amide in Liquid Ammonia

		product yield, %		
	R_3Si	12	13	8
10a	Me_3Si	73	0	13
10b	$PhMe_2Si$	37	10	19
10c	Ph_2MeSi	30	3	40
10d	Ph_3Si	29	4	38

Table III. Reaction of Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides (10) with *n*-Butyllithium in THF

		product yield, %			
	R_3Si	12	13	22	24
10a	Me_3Si	30	30		22
10b	$PhMe_2Si$	11	60		7
10c	Ph_2MeSi	0	64		9
10d	Ph_3Si	0	32	31	11



not **12**. Compound **12** was obtained in the limited cases of trimethyl- and dimethylphenylsilyl derivatives **10a** and **10b** (Table III). Simultaneously, two types of Stevens rearrangement products (**22** and/or **24**) were isolated, but **8** was not formed in any case. The structures of **22** and **24** were confirmed by spectral and elemental analyses (Tables VI and VII). The three amines **12**, **13**, and **22** are the rearrangement products produced in terms of three competing reaction paths, which start from the common

Table IV. *N,N*-Dimethyl-2-methyl-α-(triorganosilyl)benzylamines (12)[a]

	R_3Si	bp (mmHg), °C	^{1}H NMR ($CDCl_3$), δ $SiCH_3$	$ArCH_3$	NCH_3	CH
12a	Me_3Si	120-125 (12)	−0.02 (s, 9 H)	2.24 (s)	2.28 (s)	2.95 (s)
12b	$PhMe_2Si$	140-143 (3)	−0.02, 0.45 (2 s, 6 H)	2.19 (s)	2.19 (s)	3.26 (s)
12c	Ph_2MeSi	132 (0.005) [87-89][b]	0.54 (s, 3 H)	1.93 (s)	2.20 (s)	3.64 (s)
12d	Ph_3Si	[152-154][b]		1.74 (s)	2.25 (s)	3.87 (s)

[a] Satisfactory analytical data (±0.3% for C, H, and N) were submitted for review. [b] Values in brackets are melting points.

Table V. *N,N*-Dimethyl-2-[(triorganosilyl)methyl]benzylamines (13)[a]

	R_3Si	bp (mmHg), °C	^{1}H NMR ($CDCl_3$), δ $SiCH_3$	NCH_3	$SiCH_2$	NCH_2
13a	Me_3Si	108 (12)	0.02 (s, 9 H)	2.25 (s)	2.28 (s)	3.34 (s)
13b	$PhMe_2Si$	164 (3)	0.24 (s, 6 H)	2.13 (s)	2.44 (s)	3.08 (s)
13c	Ph_2MeSi	130-140 (0.005)	0.46 (s, 3 H)	2.10 (s)	2.82 (s)	2.97 (s)
13d	Ph_3Si	91-93[b]		2.03 (s)	2.83 (s)	3.13 (s)

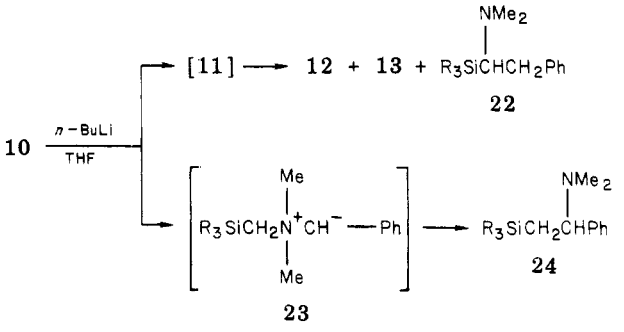
[a] Satisfactory analytical data (±0.3% for C, H, and N) were submitted for review. [b] Melting point.

Table VI. *N,N*-Dimethyl-α-[(triorganosilyl)methyl]benzylamines (24)[a] and Compound 22d[a]

	R_3Si	bp (mmHg) °C	^{1}H NMR ($CDCl_3$), δ $SiCH_3$	$SiCH_2$	NCH_3	NCH
24a	Me_3Si	103 (13)	−0.19 (s, 9 H)	1.1-1.3 (AB q, d, J_{AX} = 6.0 Hz, J_{BX} = 10.0 Hz)	2.16 (s)	3.39 (dd, J_{AX} = 6.0 Hz, J_{BX} = 10.0 Hz)
24b	$PhMe_2Si$	110-135 (3)	−0.01, 0.07 (2 s, 6 H)	1.31, 1.53 (AB q, d, J_{AB} = 14.0 Hz, J_{AX} = 5.8 Hz, J_{BX} = 10.0 Hz)	2.12 (s)	3.38 (dd, J_{AX} = 5.8 Hz, J_{BX} = 10.0 Hz)
24c	Ph_2MeSi	130-140 (0.005)	0.16 (s, 3 H)	1.67, 1.92 (AB q, d, J_{AB} = 14.5 Hz, J_{AX} = 5.8 Hz, J_{BX} = 10.0 Hz)	2.11 (s)	3.46 (dd, J_{AX} = 5.8 Hz, J_{BX} = 10.0 Hz)
24d	Ph_3Si	70-72[b]		1.90, 2.16 (AB q, d, J_{AB} = 14.5 Hz, J_{AX} = 7.0 Hz, J_{BX} = 8.5 Hz)	1.96 (s)	3.59 (dd, J_{AX} = 7.0 Hz, J_{BX} = 8.5 Hz)

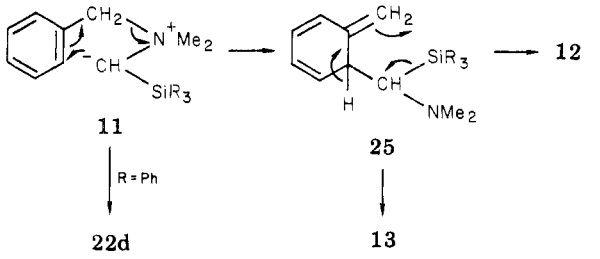
22d, $Ph_3SiCH(NMe_2)CH_2Ph$ mp 69-72 °C; NMR ($CDCl_3$) δ 2.20 (s, 6 H, NCH_3), 3.60 (dd, J_{AX} = 4.1 Hz, J_{BX} = 9.5 Hz, 1 H, SiCH), 3.01 and 3.17 (AB q, d, J_{AB} = 15.0 Hz, J_{AX} = 4.1 Hz, J_{BX} = 9.5 Hz, 2 H, $PhCH_2$), 7.15 (s, $PhCH_2$), 7.26-7.75 (m, aromatic H)

[a] Satisfactory analytical data (±0.3% for C, H, and N) were submitted for review. [b] Melting point.



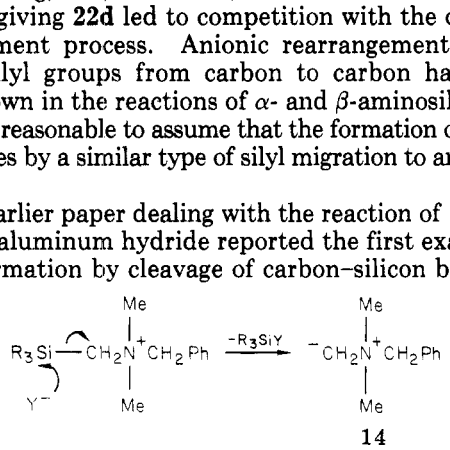
intermediate 11. The amine 24 is a Stevens product of ylide 23.

The process of the formation of 12 and 13 may be inferred as follows. The nucleophilic attack of a carbanion in the first intermediate, 11, on the aromatic ring gives the second intermediate, 25. A tautomeric proton transfer



in 25 serves to rearomatize the ring, giving a usual Sommelet–Hauser rearrangement product, 12. 1,4-Rearrangement of the silyl group from carbon to carbon proceeds, followed by a 1,2-shift of a proton to give 13. The ratio of 12 vs. 13 is influenced by both the reaction conditions and the bulkiness of the silyl group. The proton transfer is favorable at a low temperature (−35 °C in liquid ammonia). The silyl migration is accelerated at a higher temperature (0 °C in THF) and also with an increase of phenyl substituent on the silicon. A 1:1 ratio was obtained when **10a** was treated at 0 °C in THF. At the high temperature, sterically stable **13** would be formed rather than **12** since it has a sterically more crowded structure. Further, in **11d**, the triphenylsilyl group, which is the most bulky group, interferes with the attack of the anion on the benzene ring, and, as a result, the Stevens rearrangement process giving **22d** led to competition with the ortho rearrangement process. Anionic rearrangements of triorganosilyl groups from carbon to carbon have been well-known in the reactions of α- and β-aminosilanes.[7-11] It seems reasonable to assume that the formation of **13** also progresses by a similar type of silyl migration to an anionic site.

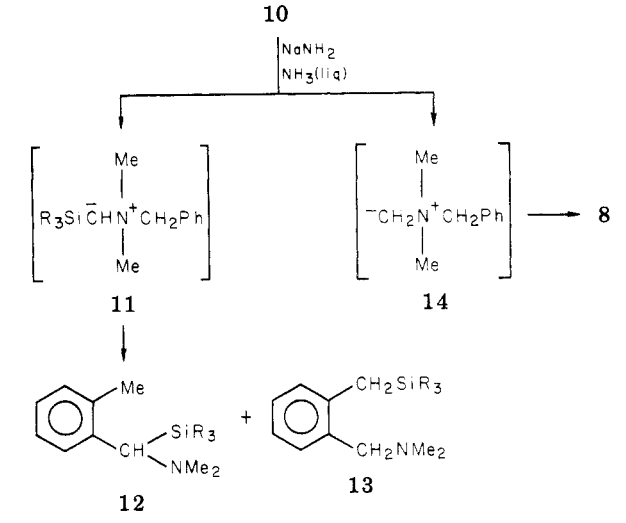
The earlier paper dealing with the reaction of **10d** with lithium aluminum hydride reported the first example of ylide formation by cleavage of carbon–silicon bonds.[12]



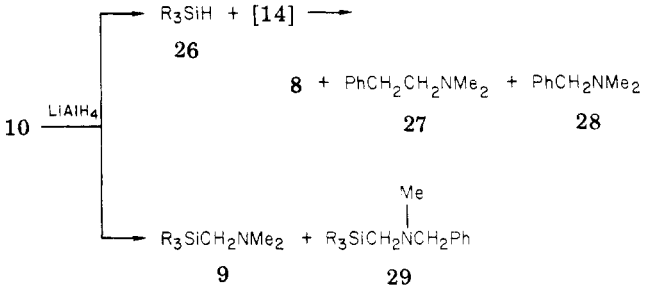
Y = NH_2^- or H^- (from AlH_4^-)

(7) Y. Sato, Y. Ban, and H. Shirai, *J. Organomet. Chem.*, **113**, 115 (1976).
(8) Y. Sato, Y. Ban, T. Aoyama, and H. Shirai, *J. Org. Chem.*, **41**, 1962 (1976).
(9) Y. Sato, T. Toyo'oka, T. Aoyama, and H. Shirai, *J. Org. Chem.*, **41**, 3559 (1976).
(10) Y. Sato, Y. Kobayashi, M. Sugiura, and H. Shirai, *J. Org. Chem.*, **43**, 199 (1978).
(11) G. Hirnbert, *J. Chem. Res. (S)*, 104 (1978).

Scheme I



The nucleophilic attack of an aluminum hydride anion on the triphenylsilyl moiety to give triphenylsilane (**26**) and **14** occurred in preference to the cleavage of carbon–nitrogen bonds. Similar treatment of **10a–c** with lithium aluminum hydride was done in order to examine the priority of the ylide formation reaction. The results are summarized in Table VIII. When a phenyl in a triphenylsilyl group was changed to a methyl, yields of **26** and the rearrangement products **8** and **27** decreased, but those of carbon–nitrogen bond cleavage products **9** and **29** increased. Thus the ylide formation from **10** by lithium aluminum hydride can be applicable to triphenylsilyl derivatives only.



Experimental Section

Melting points were determined on a Büchi SMP-20 capillary melting point apparatus and are uncorrected. ^{1}H NMR spectra were recorded on a JEOL MH-100 spectrometer. Mass spectral data were obtained by using a Hitachi M-52 instrument operating at an ionizing voltage of 20 eV. IR spectra were recorded on a JASCO IRA-2 spectrometer. GLC analyses were performed on JEOL JGC-750 and 1100 chromatographs equipped with a TCD and a FID, respectively, and using 3 mm × 1–2 m stainless-steel columns with a nitrogen flow rate of 50 mL/min. Yields were determined after measurement of relative response ratios. Preparative GLC was carried out by using a 6 mm × 2 m column with a helium flow rate of 120 mL/min.

Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides 10a–d. A solution of 30 mmol of [(dimethylamino)-methyl]triorganosilanes[9] (**9**) and 40 mmol of benzyl halides in 60 mL of ethanol was heated at reflux for 5 h. After removal of the ethanol under reduced pressure, 50 mL of ethyl acetate was added to the residual oil, and the precipitated crystals were filtered and washed with ether. The yields and analytical data are summarized in Table I.

Reaction of 10a with Sodium Amide in Liquid Ammonia. To a suspension of sodium amide in liquid ammonia, prepared

(12) Y. Sato and H. Sakakibara, *J. Organomet. Chem.*, **166**, 303 (1979).

Table VII. Mass Spectra[a] of the Reaction Products 12, 13, 22,[b] and 24

	R_3Si	formula	m/e (rel intens) 12	13	24
a	Me_3Si	$C_{13}H_{23}NSi$	221 (12, M^+), 206 (17), 148 (100)	221 (57, M^+), 177 (46), 161 (100)	221 (42, M^+), 177 (34), 134 (100)
b	$PhMe_2Si$	$C_{18}H_{25}NSi$	283 (26, M^+), 268 (18), 148 (100)	283 (24, M^+), 239 (29), 190 (100)	283 (31, M^+), 239 (23), 134 (100)
c	Ph_2MeSi	$C_{23}H_{27}NSi$	345 (5, M^+), 197 (7), 148 (100)	345 (9, M^+), 252 (100), 197 (41)	345 (4, M^+), 197 (75), 134 (100)
d	Ph_3Si	$C_{28}H_{29}NSi$	407 (4, M^+), 259 (5), 148 (100)	407 (8, M^+), 314 (100), 259 (42)	407 (5, M^+), 259 (87), 134 (100)

[a] At 20 eV. [b] $Ph_3SiCH(NMe_2)CH_2Ph$ (22d), mass spectrum, m/e (rel intens) 407 (1, M^+), 316 (26), 259 (10), 148 (100).

Table VIII. Reaction of Benzyldimethyl[(triorganosilyl)methyl]ammonium Halides (10) with Lithium Aluminum Hydride

	R_3Si	product yield, % 26	8	27	28	9	29
10a	Me_3Si	a	7	0	3	8[b]	12
10b	$PhMe_2Si$	28	14	1	4	22	11
10c	Ph_2MeSi	77	25	1	3	14	
10d	Ph_3Si	81	31	8	4	4	

[a] Not determined due to a high volatility (bp 6.7 °C). [b] Not exact.

from sodium (0.50 g, 21.7 mmol) and liquid ammonia (100 mL) according to a literature method,[13] were added crystals of **10a** (5.50 g, 18.2 mmol) at −45 °C, and then stirring was continued at −35 to −40 °C for 3 h. After evaporation of the ammonia, saturated aqueous ammonium chloride was added to the residue and the mixture extracted with ether. The ether layer was extracted with 5% HCl. The acid extract was neutralized with NaOH and extracted with ether. Distillation of the ethereal extract gave *N,N*-dimethyl-2-methylbenzylamine (**8**), bp 73–75° (10 mm), and *N,N*-dimethyl-2-methyl-α-(trimethylsilyl)benzylamine (**12a**). Yields and characterizing data are shown in Tables II, IV, and VII.

Reaction of 10b–d with Sodium Amide in Liquid Ammonia. In a manner similar to that described for **10a**, a mixture of **10b–d** (14.5 mmol) and sodium amide (prepared from 0.40 g, 17.4 mmol, of sodium) in liquid ammonia (100 mL) was stirred for 4 h at −35 to −40 °C, and then the ammonia was evaporated. After the addition of saturated aqueous ammonium chloride, the reaction mixture was extracted with ether. The ethereal extract was distilled under reduced pressure to give **8**. The residue was analyzed by GLC using a 10% Tergitol NP-35 or 10–20% silicone XE-60 column. Samples of the products (**12b–d** and **13b–d**) were isolated on Merck precoated PLC plates (silica gel 60 F-254/ethyl acetate). The results are shown in Tables II, IV, V, and VII.

***N,N*-Dimethyl-2-[(triphenylsilyl)methyl]benzylamine (13d).** This compound was prepared according to Viswanathan's method.[5] To a solution of **8** (3.00 g, 20 mmol) in ether (30 mL) was added *n*-butyllithium (10% w/v in hexane; 13 mL, 20 mmol), and stirring was continued at room temperature overnight. Then a solution of triphenylchlorosilane (5.79 g, 20 mmol) in ether (30 ml) was added, and the mixture was heated at reflux for 1.5 h. After the addition of saturated aqueous ammonium chloride, the ether layer was separated and extracted with 10% HCl. The acid extract was neutralized with NaOH and extracted with ether. The ethereal extract was dried, concentrated, and recrystallized from *n*-hexane, giving 3.52 g (43%) of **13d**.

Reaction of 1,1,3,3-Tetramethyl-1,2,3,4-tetrahydrobenzo[*d*]-1,3-azoniasiline Iodide[6] (16) with Sodium Amide in Liquid Ammonia. In a manner similar to that described for **10a**, **16** (4.00 g, 12.0 mmol) was added to a suspension of sodium amide (14.4 mmol) in liquid ammonia (80 mL), and the reaction mixture was treated as before. Distillation of the ethereal extract afforded 214 mg (12%) of **8** and 664 mg (25%) of dimethyl[2-methyl-3-[(dimethylamino)methyl]phenyl]silanol (**19**): bp 104–106 °C (2 mmHg); NMR (CCl_4) δ 0.29 (s, 6 H, $SiCH_3$), 2.08 (s, 6 H, NCH_3), 2.38 (s, 3 H, $ArCH_3$), 3.24 (s, 2 H, CH_2), 3.94 (br s, 1 H, OH), 6.80–7.32 (m, 3 H, aromatic H); IR (film) 3300 cm^{-1} (OH).

***N,N*-Dimethyl-3-bromo-2-methylbenzylamine (21).** To a Grignard reagent, prepared from 2,6-dibromotoluene[14] (**20**; 17.00 g, 68 mmol) and magnesium turnings (1.70 g, 70 mmol), in THF (50 mL), was added a solution of (dimethylamino)methyl phenyl sulfide[15] (11.4 g, 68 mmol) in THF (20 mL) at 30–35 °C. After the mixture was stirred 3 h at 40 °C, saturated aqueous ammonium chloride was added, and the THF was separated. The aqueous layer was extracted with ether. The combined organic layer was concentrated, and the residue was extracted with 10% HCl. The acid extract was neutralized with NaOH and extracted with ether. The ethereal extract was dried, concentrated, and distilled, giving 8.75 g (57%) of **21**: bp 114–118 °C (11 mmHg); NMR (CCl_4) δ 2.14 (s, 6 H, NCH_3), 2.40 (s, 3 H, $ArCH_3$), 3.30 (s, 2 H, CH_2), 6.78–7.40 (m, 3 H, aromatic H).

Dimethyl[2-methyl-3-[(dimethylamino)methyl]phenyl]-silanol (19). A solution of dimethyldichlorosilane (2.40 g, 18.6 mmol) in THF (10 mL) was added dropwise to a Grignard reagent prepared from **21** (3.49 g, 15.3 mmol) and magnesium turnings (0.40 g, 16.5 mmol) in THF (15 mL). Stirring was continued for 1 h at room temperature and then for 3 h at reflux. After the addition of a saturated potassium bicarbonate solution, the reaction mixture was extracted with benzene. The benzene extract was dried, concentrated, and chromatographed on an alumina column (benzene) to give 1.37 g (40%) of **19**.

Reaction of 10a–d with *n*-Butyllithium in THF. To a mixture of 10 mmol of **10** in 100 mL of THF was added dropwise 13 mmol of *n*-butyllithium (10% w/v in hexane) at 0 °C. Stirring was continued at 0–5 °C for 3 h and then at room temperature overnight. After the addition of saturated aqueous ammonium chloride, the THF layer was separated, and the aqueous layer was extracted with ether. The combined organic layer was dried and concentrated. The residue was analyzed by GLC using a 10% Tergitol NP-35 or a 10–20% silicone XE-60 column and separated by distillation and/or preparative TLC using Merck precoated PLC plates (silica gel 60 F-254/ethyl acetate). The results are shown in Tables III, IV, V, VI, and VII.

Reaction of 10a–d with Lithium Aluminum Hydride. A mixture of 10 mmol of **10** and 20 mmol of lithium aluminum hydride in 100 mL of THF was heated at reflux with stirring for 10 h. The reaction mixture was poured into ice–water and extracted with ether. The ether solution was extracted with 10% HCl. The ether layer was dried and distilled, giving triorganosilanes **26**.

The acid extract was neutralized with sodium carbonate and extracted with ether. The ethereal extract was dried and distilled under reduced pressure. The low-boiling distillate [bp 140 °C (15 mmHg)] was analyzed and separated by GLC (10–30% Tergitol NP-35). The high-boiling distillate was analyzed by GLC (10–20% silicone XE-60) and separated on precoated PLC plates (Merck, silica gel 60 F-254/ethyl acetate). The results are shown in Table VIII.

N-Methyl-*N*-[(trimethylsilyl)methyl]benzylamine (**29a**): bp 113–115 °C (18 mmHg); NMR ($CDCl_3$) δ 0.10 (s, 9 H, $SiCH_3$), 1.94 (s, 2 H, $SiCH_2$), 2.11 (s, 3 H, NCH_3), 3.46 (s, 2 H, NCH_2), 7.30 (s, 5 H, aromatic H). *N*-Methyl-*N*-[(dimethylphenylsilyl)-

(13) W. R. Brasen and C. R. Hauser, *Org. Synth.*, 34, 62 (1954).

(14) W. E. Truce and M. F. Amos, *J. Am. Chem. Soc.*, 73, 3013 (1951).

(15) G. F. Grillot, H. R. Felton, B. R. Garrett, H. Greenberg, R. Clementi, and M. Moskowitz, *J. Am. Chem. Soc.*, 76, 3969 (1954).

methyl]benzylamine (**29b**): bp 175 °C (14 mmHg); NMR ($CDCl_3$) δ 0.34 (s, 6 H, $SiCH_3$), 2.13 (s, 3 H, NCH_3), 2.16 (s, 2 H, $SiCH_2$), 3.40 (s, 2 H, $PhCH_2$), 7.00–7.65 (m, 10 H, aromatic H).

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Registry No. 8, 4525-48-8; **9a**, 18182-40-6; **9b**, 54926-29-3; **9c**, 54926-32-8; **9d**, 53174-43-9; **10a**, 72443-52-8; **10b**, 72443-53-9; **10c**, 72443-54-0; **10d**, 72443-55-1; **12a**, 72443-56-2; **12b**, 72443-57-3; **12c**, 72443-58-4; **12d**, 72443-59-5; **13a**, 41839-73-0; **13b**, 72443-60-8; **13c**, 72443-61-9; **13d**, 72443-62-0; **16**, 54848-55-4; **19**, 72443-63-1; **20**, 69321-60-4; **21**, 72443-64-2; **22d**, 72443-65-3; **24a**, 72443-66-4; **24b**, 72443-67-5; **24c**, 72443-68-6; **24d**, 72443-69-7; **26b**, 766-77-8; **26c**, 776-76-1; **26d**, 789-25-3; **27**, 1126-71-2; **28**, 103-83-3; **29a**, 51951-99-6; **29b**, 72443-70-0; [(dimethylamino)methyl] phenyl sulfide, 43180-39-8.

Aromatization of Dihydrothiophenes. Thiophenesaccharin: A Sweet Surprise[1,2]

Phillip A. Rossy,* Werner Hoffmann, and Norbert Müller

BASF Aktiengesellschaft, Central Laboratory, 6700 Ludwigshafen/Rhein, West Germany

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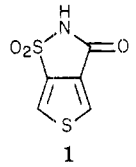
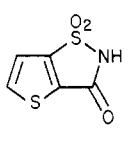
Sulfuryl choride has been shown to be highly effective in the dehydrogenation of 3,4-disubstituted-2,5-dihydrothiophenes and 2,3-disubstituted-4,5-dihydrothiophenes, in which the 3,4 and 2,3 substituents are part of a β-keto carbonyl functionality or its enol derivatives. Its use in the preparation of the key intermediate for the synthesis of the new artificial sweetener thiophenesaccharin is described.

In connection with the development of a new technically feasible synthesis of recently described new artificial sweetener thiophenesaccharins[3] [2,3-dihydro-3-oxothieno[3,4-*d*]isothiazole 1,1-dioxide (**1**), its [2,3-*d*] isomer (**2**), and its [3,2-*d*] isomer (**3**)], a mild, high-yield, operationally simple method for the aromatization of certain 3,4- and 2,3-disubstituted-dihydrothiophenes was required.



1



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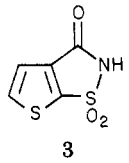

3

The literature-reported dehydrogenation reagents commonly used in thiophene synthesis are hydrogen peroxide,[4,5] perbenzoic acid,[5] phosphorus pentachloride,[3] chloranil,[6,10] selenium dioxide,[7] sulfur,[7] *N*-chlorosuccinimide,[8a] iodosobenzene,[5] nitrosobenzene,[7] and bromine.[9] Many problems have been encountered when these reagents have been used—difficulty in product isolation due to contamination with side products or reagent, long reaction times, high temperatures, and, in many cases, a large excess of a relatively expensive reagent is required with not always satisfactory results.

We have found sulfuryl chloride to be a highly efficient reagent for dehydrogenating, under mild conditions, 3,4-disubstituted-2,5-dihydrothiophenes (**4**) and 2,3-disubstituted-4,5-dihydrothiophenes (**6**), in which the 3,4 or 2,3 substituents are part of a β-keto carbonyl functionality or its enol ether derivative.[8b] Sulfuryl chloride has the advantage of being inexpensive and easy to handle, and any excess can be readily removed. The reaction is carried out by using 1–1.1 molar equiv of sulfuryl chloride and an appropriate solvent such as chloroform or methylene chloride at −10 to 0 °C. The reaction is complete within 1–2 h. The product is isolated by normal work-up procedures.

As shown in the tables, the yields are high and sensitive groups such as acetates, mesylates, thioethers, phosphates, esters, and ketones are not affected. In the aromatization of 3,4-disubstituted-2,5-dihydrothiophenes (**4a–4m**) the intermediate chloro compound spontaneously loses HCl and gives the thiophene. The intermediate chloro compounds in the 2,3-disubstituted cases (**6a–6j**) only partially lose HCl under the reaction conditions, and a base such as triethylamine is usually required to complete the reaction (see Experimental Section). The reaction can be easily scaled up without loss in yield or quality of product.

Sulfuryl chloride has been successfully used in the dehydrogenation of the key intermediates **8** (mp 182–186 °C) and **9** (mp 133–135 °C) for the syntheses of thiophenesaccharins **1** and **2** affording **10** (mp 92–95 °C) and

(1) Dedicated to Professor Dr. M. Seefelder on the occassion of his 60th birthday.

(2) Presented (in part) at the IVth International Congress of Pesticide Chemistry (IUPAC), Zürich, July 24–28, 1978.

(3) Hromatka, O.; Binder, D. Deutsche Offenlegungsschrift 2534689; *Chem. Abstr.* **1976**, *85*, 5612. The [3,4-*d*] isomer is 1000 times sweeter than sucrose and does not have the bitter metallic aftertaste characteristic of saccharin.

(4) (a) Stoll, A.; Süess, R. *Helv. Chim. Acta* **1974**, *57*, 2487. (b) Krieger, M.; Süess, R. U.S. Patent 3929833; *Chem. Abstr.* **1972**, *77*, 34295.

(5) Takaya, T.; Kosaka, S.; Otsuji, Y.; Imoti, E. *Bull. Chem. Soc. Jpn.* **1968**, *41*, 2086, 2582.

(6) Ruschig, H.; Meixner, W.; Alpermann, H. G. U.S. Patent 3445473; *Chem. Abstr.* **1967**, *67*, 21811.

(7) Kiehne, H. Deutsche Offenlegungsschrift 1945964; *Chem. Abstr.* **1971**, *74*, 141507.

(8) (a) Safir, S. R. U.S. Patent 3953430; *Chem. Abstr.* **1972**, *85*, 33101. (b) Two recent papers published after the appearance of our patent applications (see also ref 2) mention the use of sulfuryl chloride in the oxidation of similar dihydrothiophenes, affording the corresponding thiophene derivatives: Press, J. B.; Safir, S. R., et al. *J. Med. Chem.* **1979**, *22*, 725. Press, J. B. et al. *J. Org. Chem.* **1979**, *44*, 3292.

(9) Ruschig, H.; Schorr, M.; Muschaweck, R.; Rippel, R. *Deutsche Auslegungsschrift* 1643325; *Chem. Abstr.* **1969**, *71*, 91287.

(10) Chakrabarti, J. K.; Tupper, D. Belgian Patent 835932; *Chem. Abstr.* **1977**, *86*, 29893.

0022-3263/80/1945-0617$01.00/0