Article

Si- and C-Functional Organosilicon Building Blocks for Synthesis Based on 4-Silacyclohexan-1-ones Containing the Silicon Protecting Groups MOP (4-Methoxyphenyl), DMOP (2,6-Dimethoxyphenyl), or TMOP (2,4,6-Trimethoxyphenyl)

Marcel Geyer, Olle Karlsson, Johannes Armin Baus, Eric Wellner, and Reinhold Tacke

J. Org. Chem., **Just Accepted Manuscript** • DOI: 10.1021/acs.joc.5b00774 • Publication Date (Web): 30 Apr 2015

Si- and C-Functional Organosilicon Building Blocks for Synthesis Based on 4-Silacyclohexan-1-ones Containing the Silicon Protecting Groups MOP (4-Methoxyphenyl), DMOP (2,6-Dimethoxyphenyl), or TMOP (2,4,6-Trimethoxyphenyl)

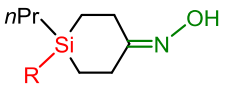
Marcel Geyer[a], Olle Karlsson[b], Johannes A. Baus[a], Eric Wellner[b], and Reinhold Tacke[a]*

[a] Institut für Anorganische Chemie, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

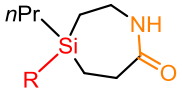
[b] AstraZeneca R&D Mölndal, CVMD Innovative Medicines, Pepparedsleden 1, SE-43183 Mölndal, Sweden

ABSTRACT: The 4-silacyclohexan-1-ones **1a**–**1c**, 4-silacyclohexan-1-one oximes **2a**–**2c**, 1,4-azasilepan-7-ones **3a**–**3c**, 1,4-azasilepanes **4a**–**4c**, and 2-bromo-4-silacyclohexan-1-ones **5a** and **5b** were prepared in multistep syntheses, starting from trimethoxypropylsilane. All these compounds represent C-functional ($R_2C{=}O$, $R_2C{=}N{-}OH$, $R{-}NH(C{=}O){-}R$, R_2NH, or $R_3C{-}Br$) silicon-containing heterocycles that contain Si–MOP, Si–DMOP, or Si–TMOP moieties (MOP = 4-methoxyphenyl, DMOP = 2,6-dimethoxyphenyl, TMOP = 2,4,6-trimethoxyphenyl), which can be cleaved under mild conditions by protodesilylation. As a proof of principle, compounds **3a**–**3c** were transformed quantitatively and selectively into the chlorosilane **6** (treatment with hydrogen chloride in dichloromethane). Thus, the C- and Si-functional compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b** represent versatile building blocks for synthesis.

1a–1c

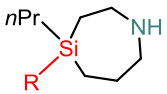


2a–2c

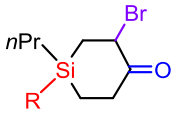


3a–3c

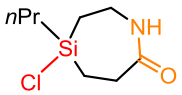
	R
1a–5a	MOP
1b–5b	DMOP
1c–4c	TMOP



4a–4c



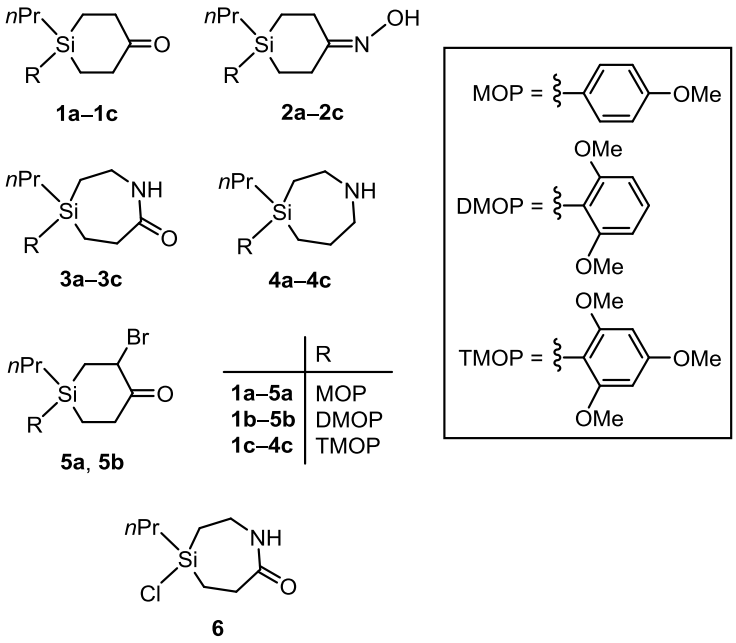
5a, **5b**



6

INTRODUCTION

In context with our systematic studies on silicon-based drugs,[1,2] we have been interested in the development of new silicon-containing building blocks for synthesis, such as 4-silapiperidines,[3] 4-silacyclohexan-1-ones,[4] and other classes of organosilicon compounds. In continuation of these studies, we have now succeeded in synthesizing a series of new 4-silacyclohexan-1-ones (**1a**–**1c**), 4-silacyclohexan-1-one oximes (**2a**–**2c**), 1,4-azasilepan-7-ones (**3a**–**3c**), 1,4-azasilepanes (**4a**–**4c**), and 2-bromo-4-silacyclohexan-1-ones (**5a** and **5b**) that contain the silicon protecting groups MOP (4-methoxyphenyl), DMOP (2,6-dimethoxyphenyl), or TMOP (2,4,6-trimethoxyphenyl). In previous studies, we have demonstrated that these three methoxy-substituted phenyl groups can be easily removed from the silicon atom of a given MOP-, DMOP-, or TMOP-silane via protodesilylation under very mild conditions to give the corresponding chloro- or methoxysilane.[5] Thus, compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b** can be regarded as versatile building blocks for synthesis that can undergo (i) a variety of transformations at their C-functional group and (ii) selective cleavage reactions of their Si–MOP, Si–DMOP, and Si–TMOP moieties. Here we report on the syntheses and characterization of **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b**. The syntheses of **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b** are based on a sequence of transformations of the keto group of **1a**–**1c**. As a proof of principle, we have also studied the cleavage of the Si–MOP, Si–DMOP, and Si–TMOP moieties of **3a**–**3c** (formation of the corresponding chlorosilane **6**).

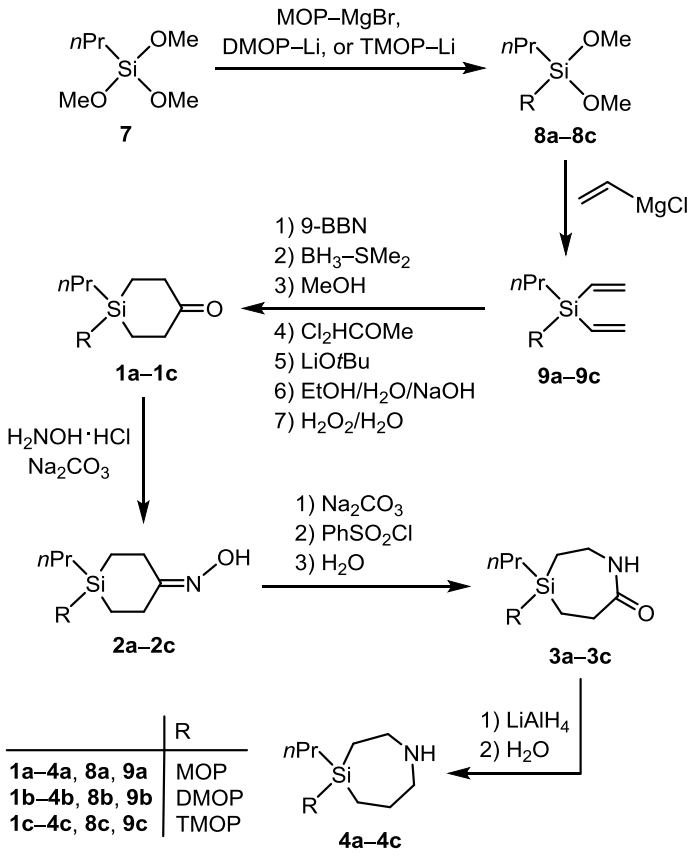


RESULTS AND DISCUSSION

Syntheses. Compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, and **4a**–**4c** were prepared in multistep syntheses according to Scheme 1, starting from trimethoxypropylsilane (**7**). Thus, treatment of **7** with (4-methoxyphenyl)magnesium bromide, (2,6-dimethoxyphenyl)lithium, or (2,4,6-trimethoxyphenyl)lithium afforded the corresponding dimethoxydiorganylsilanes **8a**–**8c**, which upon reaction with vinylmagnesium chloride furnished the respective divinyldiorganylsilanes **9a**–**9c**. In the next step, compounds **9a**–**9c** were transformed into the corresponding 4-silacyclohexan-1-ones **1a**–**1c** by using a synthetic method developed by H. C. Brown, J. A. Soderquist, et al.[6] The 4-silacyclohexan-1-one oximes **2a**–**2c** were synthesized by treatment of **1a**–**1c** with hydroxylamine hydrochloride and sodium carbonate. Sequential treatment of **2a**–**2c** with sodium carbonate and benzenesulfonyl chloride yielded the corresponding 1,4-azasilepan-7-ones **3a**–**3c**. Finally, reduction of **3a**–**3c** with lithium aluminum hydride, followed by aqueous workup, afforded the 1,4-azasilepanes **4a**–**4c**.

Compounds **1a**–**1c**, **2a**–**2c**, and **3a**–**3c** were isolated as colorless crystalline solids, whereas compounds **4a**–**4c**, **8a**–**8c**, and **9a**–**9c** were isolated as colorless liquids (for the yields, see Scheme 1).

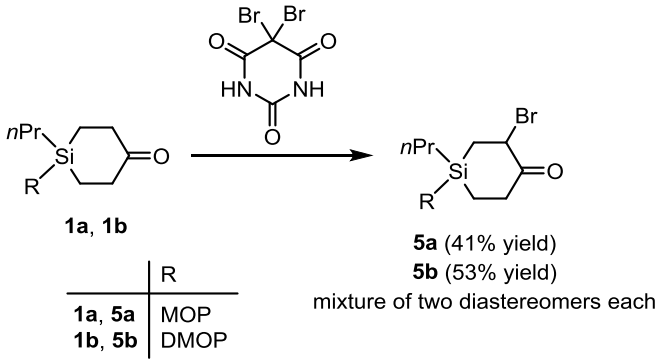
Scheme 1. Syntheses of Compounds 1a–1c, 2a–2c, 3a–3c, and 4a–4c



yields [%]					
1a: 71	**2a**: 73	**3a**: 73	**4a**: 80	**8a**: 67	**9a**: 81
1b: 83	**2b**: 67	**3b**: 66	**4b**: 78	**8b**: 58	**9b**: 88
1c: 61	**2c**: 34	**3c**: 41	**4c**: 55	**8c**: 72	**9c**: 80

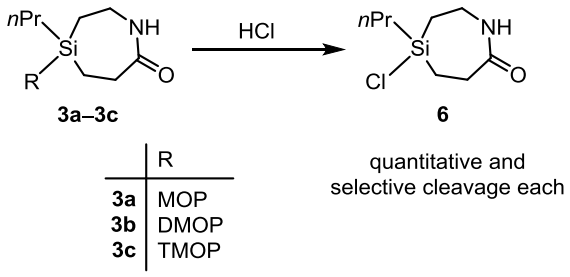
The 2-bromo-4-silacyclohexan-1-ones **5a** and **5b** were synthesized according to Scheme 2 by treatment of the 4-silacyclohexan-1-ones **1a** and **1b** with 0.5 molar equivalents of 5,5-dibromobarbituric acid (in this context, see ref 7) and were isolated in 41% (**5a**) and 53% (**5b**) yield, respectively, as colorless oils. Both compounds were obtained as a mixture of two diastereomers (molar ratios: **5a**, 1:3.8; **5b**, 1:1.1). All attempts to prepare the analogous TMOP-substituted derivative of **5a** and **5b**, starting from **1c** and using the same synthetic method and the same experimental parameters failed, due to side reactions of the reactive Si–TMOP moiety (side products could not be identified).

Scheme 2. Syntheses of Compounds 5a and 5b



As a proof of principle, the MOP, DMOP, and TMOP protecting groups of the 1,4-azasilepan-7-ones **3a**–**3c** were removed by treatment with hydrogen chloride in dichloromethane at 20 °C to give the corresponding 4-chloro-1,4-azasilepan-7-one **6** (Scheme 3). According to the different reactivities of the Si–MOP, Si–DMOP, and Si–TMOP moieties,[5a] different reaction times were necessary for these transformations (for details, see the Experimental Section). The cleavage reactions were monitored by ^{1}H, ^{13}C, and ^{29}Si NMR spectroscopic studies (see the Supporting Information; Figures S1–S9). In all cases, quantitative and selective cleavage reactions were observed to give **6** and the respective cleavage products H–MOP, H–DMOP, and H–TMOP.

Scheme 3. Syntheses of Compound 6



The identities of the new compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, **5b**, **8a**–**8c**, and **9a**–**9c** were established by NMR spectroscopic studies (^{1}H, ^{13}C, ^{29}Si) and elemental analyses (C, H, N) or mass spectrometric investigations (ESI-HRMS). In addition, compounds **3a** and

3b were characterized by crystal structure analyses. The identity of **6** was established by NMR spectroscopic studies (^{1}H, ^{13}C, ^{29}Si).

Crystal Structure Analyses. Compounds **3a** and **3b** were structurally characterized by single-crystal X-ray diffraction. The crystal data and the experimental parameters used for the crystal structure analyses are given in the Supporting Information (Table S1). The molecular structures of **3a** and **3b** are depicted in Figures 1 and 2. All the bond lengths and angles of these compounds are in the expected ranges and do not need any further discussion; however, the conformations of **3a** and **3b** deserve a brief discussion. Both compounds adopt a chair conformation of the seven-membered ring in the crystal. In the case of **3b**, the bulky 2,6-dimethoxyphenyl group occupies an equatorial position, whereas the less bulky 4-methoxyphenyl group of **3a** is found in an axial site. This finding is in agreement with the crystal structures of a series of 4-silacyclohexan-1-ones[4] and 4-silapiperidines[8] with chair conformation, where the more bulky silicon-bound substituents also occupy an equatorial site.

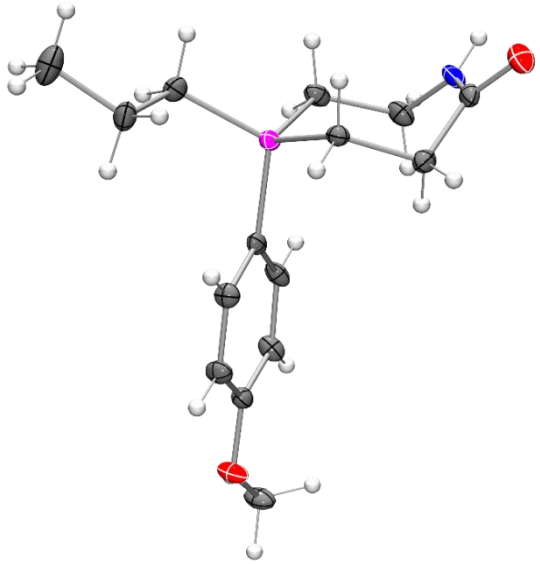


Figure 1. Molecular structure of **3a** in the crystal (probability level of displacement ellipsoids 50%).

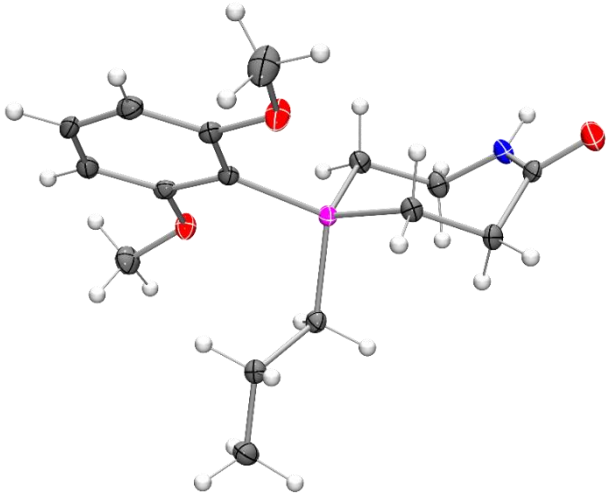


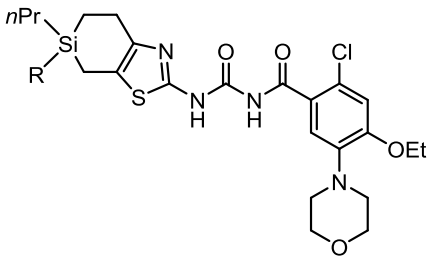
Figure 2. Molecular structure of **3b** in the crystal (probability level of displacement ellipsoids 50%).

■ CONCLUSION

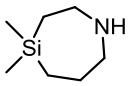
With the syntheses of compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b**, a series of new classes of silicon-containing C-functional heterocycles with an Si–MOP, Si–DMOP, or Si–TMOP moiety have been made available. These compounds were prepared in convenient multistep syntheses, starting from trimethoxypropylsilane, and were characterized by NMR spectroscopic studies (^{1}H, ^{13}C, ^{29}Si) and elemental analyses (C, H, N) or mass-spectrometric studies (ESI-HRMS). Compounds **3a** and **3b** were additionally studied by single-crystal X-ray diffraction. With their C-functional $R_2C{=}O$ (**1a**–**1c**, **5a**, **5b**), $R_2C{=}N{-}OH$ (**2a**–**2c**), R–NH(C=O)–R (**3a**–**3c**), R_2NH (**4a**–**4c**), and $R_3C{-}Br$ moieties (**5a**, **5b**), these compounds represent versatile building blocks for synthesis.

The transformations **1a**–**1c** → **2a**–**2c** → **3a**–**3c** → **4a**–**4c** and **1a/1b** → **5a**/**5b** at the aforementioned C-functional groups already demonstrate the synthetic potential of these silicon-containing heterocycles. In addition to their C-functional groups, these compounds also contain an Si-functional Si–MOP, Si–DMOP, or Si–TMOP moiety that can be cleaved under mild conditions by protodesilylation to give other Si-functionalities. As a proof of principle, compounds **3a**–**3c** were transformed quantitatively and selectively by treatment with hydrogen chloride in dichloromethane into the corresponding chlorosilane **6**. Thus, with their C- and Si-functionalities, the title compounds can be regarded as versatile building blocks for synthesis. As heterocyclic skeletons play a very important role in medicinal chemistry, the C- and Si-functional silicon-containing heterocycles **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, and **5b** represent promising building blocks for the design of new silicon-based drugs. For example, **5a** and **5b** have already been used as starting materials for the synthesis of a series of GPR81 agonists with a thiazol skeleton, such as **10** and **11**.[9] Furthermore, it should be mentioned that 4,4-dimethyl-1,4-azasilepane (**12**) has recently been demonstrated to be an antiviral agent.[10]

Scheme 4. Chemical Structures of Compounds 10–12



10: R = MOP
11: R = DMOP



12

EXPERIMENTAL SECTION

General Procedures. All syntheses in organic solvents were carried out under a dry argon or nitrogen atmosphere. The organic solvents used were dried and purified according to standard procedures and stored under dry argon. The commercial starting materials and reagents were used without further purification. The ^{1}H (500 MHz), ^{13}C (125.7 MHz), and ^{29}Si (99.3 MHz) NMR spectra were recorded at 23 °C using $CDCl_3$, CD_2Cl_2, or C_6D_6 as the solvent. Chemical shifts (ppm) were determined relative to internal $CHCl_3$ (^{1}H, δ 7.24 ppm; $CDCl_3$), $CHDCl_2$ (^{1}H, δ 5.32 ppm; CD_2Cl_2), C_6HD_5 (^{1}H, δ 7.28 ppm; C_6D_6), $CDCl_3$ (^{13}C, δ 77.0 ppm; $CDCl_3$), CD_2Cl_2 (^{13}C, δ 53.8 ppm; CD_2Cl_2), C_6D_6 (^{13}C, δ 128.0 ppm; C_6D_6), or external TMS (^{29}Si, δ 0 ppm; CD_2Cl_2, $CDCl_3$, C_6D_6). Analysis and assignment of the ^{1}H and ^{13}C NMR spectroscopic data was supported by $^{1}H,^{1}H$ gradient-selected COSY along with $^{13}C,^{1}H$ gradient-selected HMQC and HMBC experiments. Assignment of the ^{13}C NMR spectroscopic data was additionally supported by DEPT 135 experiments. Coupling constants are given as their absolute values. GC/MS spectra were recorded using solutions in dichloromethane. High-resolution mass spectra were recorded using solutions in dichloromethane (GC-FI-TOF-MS) or methanol (ESI).

*4-(4-Methoxyphenyl)-4-propyl-4-silacyclohexan-1-one (**1a**).* 9-Borabicyclo[3.3.1]nonane (11.0 g, 45.1 mmol of the 9-BBN dimer) was added in a single portion at 20 °C to a stirred solution of **9a** (9.00 g, 38.7 mmol) in *n*-heptane (150 mL), and the resulting mixture was heated under reflux for 2 h. The reaction mixture was then cooled to 20 °C, borane dimethyl sulfide complex (3.24 g, 42.6 mmol) was added in a single portion, and the resulting mixture was heated under reflux for 2 h. Subsequently, the mixture was cooled to 0 °C, methanol (8 mL) was added dropwise within 10 min, and the resulting solution was then stirred at 20 °C for 1 h. The volatile components were removed under reduced pressure at 40 °C, and the oily residue was dissolved in tetrahydrofuran (100 mL), followed by the addition of

dichloromethyl methyl ether (6.68 g, 58.1 mmol) in a single portion at 0 °C. Subsequently, a 1 M solution of lithium *tert*-butoxide in tetrahydrofuran (194 mL, 194 mmol) was added dropwise at 0 °C within 30 min, and the reaction mixture was stirred at 0 °C for 10 min and then at 20 °C for 1 h, followed by sequential addition of ethanol (50 mL), water (50 mL), and sodium hydroxide (4.65 g, 116 mmol). The resulting mixture was cooled to 0 °C, and an aqueous solution of hydrogen peroxide (35 weight%, 33.9 mL) was added dropwise within 30 min. The mixture was then stirred at 20 °C for 16 h, followed by the addition of water (200 mL). The organic phase was separated, the aqueous layer was extracted with diethyl ether (3 × 100 mL) and discarded, the combined organic extracts were dried over anhydrous sodium sulfate, and the solvent was removed under reduced pressure. The residue was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 340 g; eluent, *n*-heptane/ethyl acetate (8/2 v/v)), followed by bulb-to-bulb distillation in vacuo (142–144 °C/0.1 mbar) to furnish **1a** in 71% yield as a colorless crystalline solid (7.21 g, 27.5 mmol). ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.82−0.89 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.93−0.99 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.11–1.19 and 1.21–1.29 (m, 4 H; SiC*H*$_2$CH$_2$C), 1.34−1.44 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.45−2.58 (m, 4 H; SiCH$_2$C*H*$_2$C), 3.81 (s, 3 H; C$_6$H$_4$OC*H*$_3$), 6.93−6.95 (m, 2 H; *H*-2/*H*-6, C$_6$H$_4$OCH$_3$), 7.48−7.50 ppm (m, 2 H; *H*-3/*H*-5, C$_6$H$_4$OCH$_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 8.5 (Si*C*H$_2$CH$_2$C), 16.4 (Si*C*H$_2$CH$_2$CH$_3$), 17.7 (SiCH$_2$*C*H$_2$CH$_3$), 18.3 (SiCH$_2$CH$_2$*C*H$_3$), 38.2 (SiCH$_2$*C*H$_2$C), 55.4 (C$_6$H$_4$O*C*H$_3$), 114.2 (*C*-3/*C*-5, C$_6$H$_4$OCH$_3$), 126.8 (*C*-1, C$_6$H$_4$OCH$_3$), 135.7 (*C*-2/*C*-6, C$_6$H$_4$OCH$_3$), 161.2 (*C*-4, C$_6$H$_4$OCH$_3$), 214.3 ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −7.1 ppm. HRMS: *m*/*z* [*M* + H]$^+$ calcd for $C_{15}H_{22}O_2Si$: 263.1467; found: 263.1484.

*4-(2,6-Dimethoxyphenyl)-4-propyl-4-silacyclohexan-1-one (**1b**).* Compound **1b** was synthesized by using the same procedure as described for the preparation of **1a**, starting from **9b** (20.0 g, 76.2 mmol). The product was purified by automated flash column

chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 340 g; eluent, *n*-heptane/ethyl acetate (8/2 v/v)), followed by bulb-to-bulb distillation in vacuo (156–158 °C/0.1 mbar) to furnish **1b** in 83% yield as a colorless crystalline solid (18.6 g, 63.6 mmol). ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.85−0.90 (m, 2 H; SiCH_2CH$_2$CH$_3$), 0.90−0.95 (m, 3 H; SiCH$_2$CH$_2$CH_3), 1.14–1.22 and 1.32–1.38 (m, 4 H; SiCH_2CH$_2$C), 1.38−1.46 (m, 2 H; SiCH$_2$CH_2CH$_3$), 2.47−2.53 (m, 4 H; SiCH$_2$CH_2C), 3.75 (s, 6 H; C$_6$H$_3$(OCH_3)$_2$), 6.52 (d, $^{3}J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, C$_6$H$_3$(OCH$_3$)$_2$), 7.31 ppm (t, $^{3}J_{HH}$ = 8.3 Hz, 1 H; *H*-4, C$_6$H$_3$(OCH$_3$)$_2$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 10.9 (Si*C*H$_2$CH$_2$C), 17.1 (Si*C*H$_2$CH$_2$CH$_3$), 18.0 (SiCH$_2$*C*H$_2$CH$_3$), 18.3 (SiCH$_2$CH$_2$*C*H$_3$), 38.7 (SiCH$_2$*C*H$_2$C), 55.5 (C$_6$H$_3$(O*C*H$_3$)$_2$), 103.7 (*C*-3/*C*-5, C$_6$H$_3$(OCH$_3$)$_2$), 110.8 (*C*-1, C$_6$H$_3$(OCH$_3$)$_2$), 132.3 (*C*-4, C$_6$H$_3$(OCH$_3$)$_2$), 166.1 (*C*-2/*C*-6, C$_6$H$_3$(OCH$_3$)$_2$), 215.7 ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −7.6 ppm. HRMS: *m*/*z* $[M + H]^+$ calcd for $C_{16}H_{24}O_3Si$: 293.1573; found: 293.1584.

*4-Propyl-4-(2,4,6-trimethoxyphenyl)-4-silacyclohexan-1-one (**1c**).* Compound **1c** was synthesized by using the same procedure as described for the preparation of **1a**, starting from **9c** (16.0 g, 54.7 mmol). The product was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 340 g; eluent, *n*-heptane/ethyl acetate/triethylamine (80/20/5 v/v/v)), followed by bulb-to-bulb distillation in vacuo (189–190 °C/0.3 mbar) to furnish **1c** in 61% yield as a colorless crystalline solid (10.8 g, 33.5 mmol). ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.82−0.87 (m, 2 H; SiCH_2CH$_2$CH$_3$), 0.90−0.95 (m, 3 H; SiCH$_2$CH$_2$CH_3), 1.10–1.18 and 1.31–1.39 (m, 4 H; SiCH_2CH$_2$C), 1.34−1.42 (m, 2 H; SiCH$_2$CH_2CH$_3$), 2.46−2.51 (m, 4 H; SiCH$_2$CH_2C), 3.73 (s, 6 H; *o*-OCH_3, C$_6$H$_2$(OCH$_3$)$_3$), 3.81 (s, 3 H; *p*-OCH_3, C$_6$H$_2$(OCH$_3$)$_3$), 6.09 ppm (s, 2 H; *H*-3/*H*-5, C$_6$H$_2$(OCH$_3$)$_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 11.0 (Si*C*H$_2$CH$_2$C), 17.3 (Si*C*H$_2$CH$_2$CH$_3$), 18.0 (SiCH$_2$*C*H$_2$CH$_3$), 18.3 (SiCH$_2$CH$_2$*C*H$_3$), 38.8 (SiCH$_2$*C*H$_2$C), 55.4 (*p*-O*C*H$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 55.6 (*o*-O*C*H$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 90.6 (*C*-3/*C*-5, C$_6$H$_2$(OCH$_3$)$_3$), 102.1 (*C*-1, C$_6$H$_2$(OCH$_3$)$_3$), 164.1 (*C*-4

$C_6H_2(OCH_3)_3$), 167.0 (*C*-2/*C*-6, $C_6H_2(OCH_3)_3$), 215.8 ppm ($SiCH_2CH_2C$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −8.3 ppm. HRMS: *m*/*z* $[M + H]^+$ calcd for $C_{17}H_{26}O_4Si$: 323.1679; found: 323.1665.

*4-(4-Methoxyphenyl)-4-propyl-4-silacyclohexan-1-one Oxime (**2a**).* Hydroxylamine hydrochloride (530 mg, 7.63 mmol) and sodium carbonate (1.21 g, 11.4 mmol) were added in a single portion each at 20 °C to a stirred solution of **1a** (1.00 g, 3.81 mmol) in a mixture of acetonitrile (40 mL) and water (40 mL), and the reaction mixture was then stirred at 20 °C for 16 h. Subsequently, dichloromethane (100 mL) and a saturated aqueous sodium hydrogen carbonate solution (50 mL) were added sequentially, the organic layer was separated, and the aqueous layer was extracted with dichloromethane (3 × 30 mL) and discarded. The combined organic extracts were dried over anhydrous sodium sulfate, the solvent was removed under reduced pressure, and the residue was purified by column chromatography on silica gel (40–63 μm, 100 g; eluent, *n*-hexane/ethyl acetate (8/2 v/v)) to furnish **2a** in 73% yield as a colorless crystalline solid (772 mg, 2.78 mmol). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.78−0.83 (m, 2 H; $SiCH_2CH_2CH_3$), 0.92−0.96 (m, 3 H; $SiCH_2CH_2CH_3$), 0.96–1.04 and 1.06–1.17 (m, 4 H; $SiCH_2CH_2C$), 1.32−1.41 (m, 2 H; $SiCH_2CH_2CH_3$), 2.36−2.57 and 2.77−2.85 (m, 4 H; $SiCH_2CH_2C$), 3.88 (s, 3 H; $C_6H_4OCH_3$), 6.91−6.95 (m, 2 H; *H*-2/*H*-6, $C_6H_4OCH_3$), 7.44−7.49 (m, 2 H; *H*-3/*H*-5, $C_6H_4OCH_3$), 8.01 ppm (br. s, 1 H; O*H*). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 8.1 and 10.1 ($SiCH_2CH_2C$), 16.5 ($SiCH_2CH_2CH_3$), 17.7 ($SiCH_2CH_2CH_3$), 18.4 ($SiCH_2CH_2CH_3$), 21.4 and 29.2 ($SiCH_2CH_2C$), 55.3 ($C_6H_4OCH_3$), 114.1 (*C*-2/*C*-6, $C_6H_4OCH_3$), 127.4 (*C*-1, $C_6H_4OCH_3$), 135.7 (*C*-3/*C*-5, $C_6H_4OCH_3$), 161.1 (*C*-4, $C_6H_4OCH_3$), 163.5 ppm ($SiCH_2CH_2C$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −6.2 ppm. Anal. Calcd for $C_{15}H_{23}NO_2Si$: C, 64.94; H, 8.36; N, 5.05. Found: C, 65.2; H, 8.6; N, 5.3.

*4-(2,6-Dimethoxyphenyl)-4-propyl-4-silacyclohexan-1-one Oxime (**2b**).* Compound **2b** was synthesized by using the same procedure as described for the preparation of **2a**, starting

from **1b** (1.00 g, 3.42 mmol). The product was purified by column chromatography on silica gel (40–63 μm, 100 g; eluent, *n*-hexane/ethyl acetate (8/2 v/v)) to furnish **2b** in 67% yield as a colorless crystalline solid (708 mg, 2.30 mmol). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.80−0.85 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.89−0.93 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.01–1.10 and 1.18–1.26 (m, 4 H; SiC*H*$_2$CH$_2$C), 1.26−1.38 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.34−2.47 and 2.59−2.74 (m, 4 H; SiCH$_2$C*H*$_2$C), 3.74 (s, 6 H; C$_6$H$_3$(OC*H*$_3$)$_2$), 6.50 (d, $^{3}J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, C$_6$H$_3$(OCH$_3$)$_2$), 7.28 (t, $^{3}J_{HH}$ = 8.3 Hz, 1 H; *H*-4, C$_6$H$_3$(OCH$_3$)$_2$), 8.10 ppm (br. s, 1 H; O*H*). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 10.2 and 12.6 (Si*C*H$_2$CH$_2$C), 17.1 (Si*C*H$_2$CH$_2$CH$_3$), 18.0 (SiCH$_2$*C*H$_2$CH$_3$), 18.3 (SiCH$_2$CH$_2$*C*H$_3$), 21.8 and 29.4 (SiCH$_2$*C*H$_2$C), 55.5 (C$_6$H$_3$(O*C*H$_3$)$_2$), 103.7 (*C*-3/*C*-5, C$_6$H$_3$(OCH$_3$)$_2$), 111.4 (*C*-1, C$_6$H$_3$(OCH$_3$)$_2$), 132.1 (*C*-4, C$_6$H$_3$(OCH$_3$)$_2$), 164.7 (SiCH$_2$CH$_2$*C*), 166.0 ppm (*C*-2/*C*-6, C$_6$H$_3$(OCH$_3$)$_2$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −6.6 ppm. Anal. Calcd for $C_{16}H_{25}NO_3Si$: C, 62.50; H, 8.20; N, 4.56. Found: C, 62.7; H, 8.1; N, 4.5.

*4-Propyl-4-(2,4,6-trimethoxyphenyl)-4-silacyclohexan-1-one Oxime (**2c**).* Compound **2c** was synthesized by using the same procedure as described for the preparation of **2a**, starting from **1c** (1.00 g, 3.10 mmol). The product was purified by column chromatography on silica gel (40–63 μm, 100 g; eluent, *n*-hexane/ethyl acetate (8/2 v/v)) to furnish **2c** in 34% yield as a colorless crystalline solid (354 mg, 1.05 mmol). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.76−0.82 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.88−0.93 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 0.97–1.06 and 1.15–1.24 (m, 4 H; SiC*H*$_2$CH$_2$C), 1.26−1.37 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.33−2.46 and 2.59−2.72 (m, 4 H; SiCH$_2$C*H*$_2$C), 3.72 (s, 6 H; *o*-OC*H*$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 3.80 (s, 3 H; *p*-OC*H*$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 6.08 (s, 2 H; *H*-3/*H*-5, C$_6$H$_2$(OCH$_3$)$_3$), 8.01 ppm (br. s, 1 H; O*H*). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 10.3 and 12.7 (Si*C*H$_2$CH$_2$C), 17.2 (Si*C*H$_2$CH$_2$CH$_3$), 18.0 (SiCH$_2$*C*H$_2$CH$_3$), 18.3 (SiCH$_2$CH$_2$*C*H$_3$), 21.8 and 29.5 (SiCH$_2$*C*H$_2$C), 55.4 (*o*-O*C*H$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 55.5 (*p*-O*C*H$_3$, C$_6$H$_2$(OCH$_3$)$_3$), 90.6 (*C*-3/*C*-5, C$_6$H$_2$(OCH$_3$)$_3$), 102.7 (*C*-1, C$_6$H$_2$(OCH$_3$)$_3$), 163.9 (*C*-4, C$_6$H$_2$(OCH$_3$)$_3$), 164.7 (SiCH$_2$CH$_2$*C*), 167.0 ppm (*C*-2/*C*-6, C$_6$H$_2$(OCH$_3$)$_3$). ^{29}Si NMR

(99.3 MHz, CD_2Cl_2): δ −7.2 ppm. Anal. Calcd for $C_{17}H_{27}NO_4Si$: C, 60.50; H, 8.06; N, 4.15. Found: C, 60.4; H, 8.4; N, 3.9.

*4-(4-Methoxyphenyl)-4-propyl-1,4-azasilepan-7-one (**3a**)*. Sodium carbonate (848 mg, 8.00 mmol) was added in a single portion at 20 °C to a stirred solution of **2a** (2.11 g, 7.61 mmol) in a mixture of acetonitrile (100 mL) and water (100 mL), and the resulting mixture was then cooled to 0 °C, followed by dropwise addition of benzenesulfonyl chloride (2.68 g, 15.2 mmol) within 5 min. After the addition was complete, the reaction mixture was warmed to 20 °C and stirred for 24 h. Subsequently, dichloromethane (100 mL) and a saturated aqueous sodium hydrogen carbonate solution (50 mL) were added sequentially, the organic layer was separated, and the aqueous layer was extracted with dichloromethane (3 × 50 mL) and discarded. The combined organic extracts were dried over anhydrous sodium sulfate, the solvents were removed under reduced pressure, and the residue was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 100 g; eluent, dichloromethane/methanol (97/3 v/v)). The resulting colorless oil was crystallized from *n*-hexane/ethyl acetate (9/1 v/v; slow cooling of a saturated boiling solution to 20 °C), and the product was isolated by filtration and dried in vacuo to furnish **3a** in 73% yield as a colorless crystalline solid (1.54 g, 5.55 mmol). ^{1}H NMR (500.0 MHz, $CDCl_3$): δ 0.70−0.77 (m, 2 H; Si$CH_2$$CH_2$$CH_3$), 0.87−0.92 (m, 3 H; Si$CH_2CH_2CH_3$), 0.96−1.10 (m, 2 H; Si$CH_2$$CH_2$C), 1.13−1.25 (m, 2 H; Si$CH_2$$CH_2$N), 1.25−1.34 (m, 2 H; Si$CH_2CH_2CH_3$), 2.49−2.58 (m, 2 H; SiCH_2CH_2C), 3.32−3.44 (m, 2 H; SiCH_2CH_2N), 3.79 (s, 3 H; $C_6H_4OCH_3$), 6.44 (br. s, 1 H; N*H*), 6.88−6.93 (m, 2 H; *H*-2/*H*-6, $C_6H_4OCH_3$), 7.37−7.42 ppm (m, 2 H; *H*-3/*H*-5, $C_6H_4OCH_3$). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 7.6 (SiCH_2CH_2C), 14.6 (Si$CH_2CH_2CH_3$), 16.6 (SiCH_2CH_2N), 17.1 (Si$CH_2CH_2CH_3$), 18.2 (Si$CH_2CH_2CH_3$), 28.5 (SiCH_2CH_2C), 38.3 (SiCH_2CH_2N), 55.0 ($C_6H_4OCH_3$), 113.9 (*C*-2/*C*-6, $C_6H_4OCH_3$), 126.3 (*C*-1, $C_6H_4OCH_3$), 135.3 (*C*-3/*C*-5, $C_6H_4OCH_3$), 160.7 (*C*-4, $C_6H_4OCH_3$), 178.5 ppm (SiCH_2CH_2C). ^{29}Si NMR

(99.3 MHz, $CDCl_3$): δ −4.9 ppm. HRMS: *m*/*z* [*M* + H]$^+$ calcd for $C_{15}H_{23}NO_2Si$: 278.1576; found: 278.1580.

*4-(2,6-Dimethoxyphenyl)-4-propyl-1,4-azasilepan-7-one (**3b**).* Compound **3b** was synthesized by using the same procedure as described for the preparation of **3a**, starting from **2a** (2.20 g, 7.16 mmol). The product was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 100 g; eluent, dichloromethane/methanol (97/3 v/v)). The resulting colorless oil was crystallized from diethyl ether (slow cooling of a saturated boiling solution to −20 °C), and the product was isolated by filtration and dried in vacuo to furnish **3b** in 66% yield as a colorless crystalline solid (1.45 g, 4.72 mmol). ^{1}H NMR (500.0 MHz, $CDCl_3$): δ 0.80−0.86 (m, 2 H; Si$CH_2$$CH_2CH_3$), 0.87−0.92 (m, 3 H; $SiCH_2CH_2CH_3$), 1.00−1.15 (m, 2 H; SiCH_2CH_2C), 1.25−1.34 (m, 2 H; SiCH_2CH_2N), 1.33−1.42 (m, 2 H; $SiCH_2CH_2CH_3$), 2.50−2.63 (m, 2 H; $SiCH_2CH_2$C), 3.36−3.50 (m, 2 H; $SiCH_2CH_2$N), 3.73 (s, 6 H; $C_6H_3(OCH_3)_2$), 6.01 (br. s, 1 H; N*H*), 6.48 (d, $^3J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, $C_6H_3(OCH_3)_2$), 7.28 ppm (t, $^3J_{HH}$ = 8.3 Hz, 1 H; *H*-4, $C_6H_3(OCH_3)_2$). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ 10.0 (SiCH_2CH_2C), 16.8 (Si$CH_2CH_2CH_3$), 17.2 (SiCH_2CH_2N), 17.5 ($SiCH_2CH_2CH_3$), 18.3 ($SiCH_2CH_2CH_3$), 28.9 ($SiCH_2CH_2$C), 39.1 ($SiCH_2CH_2$N), 55.1 ($C_6H_3(OCH_3)_2$), 103.4 (*C*-3/*C*-5, $C_6H_3(OCH_3)_2$), 110.7 (*C*-1, $C_6H_3(OCH_3)_2$), 132.0 (*C*-4, $C_6H_3(OCH_3)_2$), 165.5 (*C*-2/*C*-6, $C_6H_3(OCH_3)_2$), 179.2 ppm ($SiCH_2CH_2C$). ^{29}Si NMR (99.3 MHz, $CDCl_3$): δ −5.0 ppm. HRMS: *m*/*z* [*M* + H]$^+$ calcd for $C_{16}H_{25}NO_3Si$: 308.1676; found: 308.1690.

*4-Propyl-4-(2,4,6-trimethoxyphenyl)-1,4-azasilepan-7-one (**3c**).* Compound **3c** was synthesized by using the same procedure as described for the preparation of **3a**, starting from **2c** (2.21 g, 6.55 mmol). The product was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 100 g; eluent, dichloromethane/methanol/triethylamine (97/3/5 v/v/v)). The resulting colorless oil was

crystallized from *n*-hexane (slow cooling of a saturated boiling solution to 20 °C), and the product was isolated by filtration and dried in vacuo to furnish **3c** in 41% yield as a colorless crystalline solid (903 mg, 2.68 mmol). ^{1}H NMR (500.0 MHz, C_6D_6): δ 0.99−1.04 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 1.05−1.08 and 1.28−1.37 (m, 2 H; SiC*H*$_2$CH$_2$C), 1.09−1.14 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.34−1.42 and 1.62−1.70 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.48−1.58 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.68−2.76 and 2.79−2.87 (m, 2 H; SiCH$_2$C*H*$_2$C), 3.09−3.24 (m, 2 H; SiCH$_2$C*H*$_2$N), 3.31 (s, 6 H; *o*-OC*H*$_3$, $C_6H_2(OCH_3)_3$), 3.48 (s, 3 H; *p*-OC*H*$_3$, $C_6H_2(OCH_3)_3$), 6.10 (s, 2 H; *H*-3/*H*-5, $C_6H_2(OCH_3)_3$), 6.58 ppm (br. s, 1 H; N*H*). ^{13}C NMR (125.7 MHz, C_6D_6): δ 10.7 (Si*C*H$_2$CH$_2$C), 17.75 (Si*C*H$_2$CH$_2$CH$_3$), 17.76 (Si*C*H$_2$CH$_2$N), 18.0 (SiCH$_2$*C*H$_2$CH$_3$), 18.6 (SiCH$_2$CH$_2$*C*H$_3$), 29.5 (SiCH$_2$*C*H$_2$C), 38.8 (SiCH$_2$*C*H$_2$N), 54.5 (*o*-O*C*H$_3$, $C_6H_2(OCH_3)_3$), 54.7 (*p*-O*C*H$_3$, $C_6H_2(OCH_3)_3$), 90.8 (*C*-3/*C*-5, $C_6H_2(OCH_3)_3$), 102.8 (*C*-1, $C_6H_2(OCH_3)_3$), 164.1 (*C*-4, $C_6H_2(OCH_3)_3$), 166.9 (*C*-2/*C*-6, $C_6H_2(OCH_3)_3$), 177.9 ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.3 MHz, C_6D_6): δ −5.5 ppm. HRMS: *m*/*z* [*M* + Na]$^+$ calcd for $C_{17}H_{27}NO_4Si$: 360.1607; found: 360.1592.

*4-(4-Methoxyphenyl)-4-propyl-1,4-azasilepane (**4a**).* A 1 M solution of lithium aluminum hydride in tetrahydrofuran (4.97 mL, 4.97 mmol of $LiAlH_4$) was added dropwise at 0 °C within 5 min to a stirred solution of **3a** (690 mg, 2.49 mmol) in diethyl ether (50 mL), and the reaction mixture was then stirred at 20 °C for 2 h. Subsequently, diethyl ether (50 mL) and water (50 mL) were added sequentially, the organic layer was separated, and the aqueous layer was extracted with diethyl ether (3 × 30 mL) and discarded. The combined organic extracts were dried over anhydrous sodium sulfate, the solvent was removed under reduced pressure, and the residue was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 50 g; eluent, ethyl acetate/triethylamine, (95/5 v/v)), followed by bulb-to-bulb distillation in vacuo to furnish **4a** in 80% yield as a colorless oil (521 mg, 1.98 mmol); bp 125−126 °C/0.1 mbar. ^{1}H NMR (500.0 MHz, C_6D_6): δ 0.97−1.04

(m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 1.01−1.07 (m, 2 H; SiC*H*$_2$CH$_2$CH$_2$N), 1.10−1.17 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.16 (br. s, 1 H; N*H*), 1.20−1.37 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.50−1.60 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 1.74−1.85 (m, 2 H; SiCH$_2$C*H*$_2$CH$_2$N), 2.62−2.75 (m, 2 H; SiCH$_2$CH$_2$C*H*$_2$N), 2.85−2.96 (m, 2 H; SiCH$_2$C*H*$_2$N), 3.48 (s, 3 H; C$_6$H$_4$OC*H*$_3$), 7.01−7.06 (m, 2 H; *H*-2/*H*-6, C$_6$H$_4$OCH$_3$), 7.63−7.68 ppm (m, 2 H; *H*-3/*H*-5, C$_6$H$_4$OCH$_3$). ^{13}C NMR (125.7 MHz, C$_6$D$_6$): δ 12.4 (Si*C*H$_2$CH$_2$CH$_2$N), 17.2 (Si*C*H$_2$CH$_2$N), 18.1 (Si*C*H$_2$CH$_2$CH$_3$), 18.5 (SiCH$_2$*C*H$_2$CH$_3$), 18.8 (SiCH$_2$CH$_2$*C*H$_3$), 27.7 (SiCH$_2$*C*H$_2$CH$_2$N), 46.0 (SiCH$_2$*C*H$_2$N), 52.1 (SiCH$_2$CH$_2$*C*H$_2$N), 54.5 (C$_6$H$_4$O*C*H$_3$), 113.9 (*C*-2/*C*-6, C$_6$H$_4$OCH$_3$), 130.7 (*C*-1, C$_6$H$_4$OCH$_3$), 135.8 (*C*-3/*C*-5, C$_6$H$_4$OCH$_3$), 160.7 ppm (*C*-4, C$_6$H$_4$OCH$_3$). ^{29}Si NMR (99.4 MHz, C$_6$D$_6$): δ 0.0 ppm. HRMS: *m*/*z* [*M* + H]$^+$ calcd for C$_{15}$H$_{25}$NOSi: 264.1784; found: 264.1801.

*4-(2,6-Dimethoxyphenyl)-4-propyl-1,4-azasilepane (**4b**).* Compound **4b** was synthesized by using the same procedure as described for the preparation of **4a**, starting from **3b** (468 mg, 1.52 mmol). The product was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 25 g; eluent, ethyl acetate/triethylamine (95/5 v/v)), followed by bulb-to-bulb distillation in vacuo to furnish **4b** in 78% yield as a colorless oil (348 mg, 1.19 mmol); bp 128−129 °C/0.01 mbar. ^{1}H NMR (500.0 MHz, C$_6$D$_6$): δ 1.13−1.18 and 1.54−1.60 (m, 2 H; SiC*H*$_2$CH$_2$CH$_2$N), 1.15−1.19 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.19−1.22 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 1.24 (br. s, 1 H; N*H*), 1.40−1.47 and 1.73−1.80 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.64−1.72 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 1.86−2.04 (m, 2 H; SiCH$_2$C*H*$_2$CH$_2$N), 2.77−2.83 and 2.87−2.94 (m, 2 H; SiCH$_2$CH$_2$C*H*$_2$N), 3.08−3.20 (m, 2 H; SiCH$_2$C*H*$_2$N), 3.45 (s, 6 H; C$_6$H$_3$(OC*H*$_3$)$_2$), 6.42 (d, $^3J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, C$_6$H$_3$(OCH$_3$)$_2$), 7.26 ppm (t, $^3J_{HH}$ = 8.3 Hz, 1 H; *H*-4, C$_6$H$_3$(OCH$_3$)$_2$). ^{13}C NMR (125.7 MHz, C$_6$D$_6$): δ 15.0 (Si*C*H$_2$CH$_2$CH$_2$N), 18.6 (Si*C*H$_2$CH$_2$N), 18.8 (Si*C*H$_2$CH$_2$CH$_3$), 19.6 (SiCH$_2$*C*H$_2$CH$_3$), 20.1 (SiCH$_2$CH$_2$*C*H$_3$), 28.2 (SiCH$_2$*C*H$_2$CH$_2$N), 46.1 (SiCH$_2$*C*H$_2$N), 51.7 (SiCH$_2$CH$_2$*C*H$_2$N), 54.7 (C$_6$H$_3$(O*C*H$_3$)$_2$), 103.8 (*C*-3/*C*-5, C$_6$H$_3$(OCH$_3$)$_2$), 114.6 (*C*-1, C$_6$H$_3$(OCH$_3$)$_2$), 131.1 (*C*-4, C$_6$H$_3$(OCH$_3$)$_2$), 165.6 ppm

(*C*-2/*C*-6, $C_6H_3(OCH_3)_2$). ^{29}Si NMR (99.4 MHz, C_6D_6): δ −0.3 ppm. HRMS: *m*/*z* $[M + H]^+$ calcd for $C_{16}H_{27}NO_2Si$: 294.1889; found: 294.1872.

*4-Propyl-4-(2,4,6-trimethoxyphenyl)-1,4-azasilepane (**4c**).* Compound **4c** was synthesized by using the same procedure as described for the preparation of **4a**, starting from **3c** (590 mg, 1.75 mmol). The product was purified by automated flash column chromatography on silica gel (Biotage SNAP cartridge, KP-Sil, 25 g; eluent, ethyl acetate/triethylamine (95/5 v/v)) to furnish **4c** in 55% yield as a colorless oil (311 mg, 961 µmol). ^{1}H NMR (500.0 MHz, C_6D_6): δ 1.14−1.20 and 1.54−1.60 (m, 2 H; SiC*H*$_2$CH$_2$CH$_2$N), 1.18−1.22 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.19−1.23 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 1.39−1.48 and 1.73−1.80 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.49 (br. s, 1 H; N*H*), 1.66−1.77 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 1.77−2.07 (m, 2 H; SiCH$_2$C*H*$_2$CH$_2$N), 2.83−2.89 and 2.92−2.99 (m, 2 H; SiCH$_2$CH$_2$C*H*$_2$N), 3.12−3.35 (m, 2 H; SiCH$_2$C*H*$_2$N), 3.42 (s, 6 H; *o*-OC*H*$_3$, $C_6H_2(OCH_3)_3$), 3.51 (s, 3 H; *p*-OC*H*$_3$, $C_6H_2(OCH_3)_3$), 6.17 ppm (s, 2 H; *H*-3/*H*-5, $C_6H_2(OCH_3)_3$). ^{13}C NMR (125.7 MHz, C_6D_6): δ 15.1 (Si*C*H$_2$CH$_2$CH$_2$N), 18.6 (Si*C*H$_2$CH$_2$N), 18.9 (Si*C*H$_2$CH$_2$CH$_3$), 19.6 (SiCH$_2$*C*H$_2$CH$_3$), 20.1 (SiCH$_2$CH$_2$*C*H$_3$), 28.2 (SiCH$_2$*C*H$_2$CH$_2$N), 46.3 (SiCH$_2$*C*H$_2$N), 51.8 (SiCH$_2$CH$_2$*C*H$_2$N), 54.6 (*p*-O*C*H$_3$, $C_6H_2(OCH_3)_3$ and *o*-O*C*H$_3$, $C_6H_2(OCH_3)_3$), 90.8 (*C*-3/*C*-5, $C_6H_2(OCH_3)_3$), 105.7 (*C*-1, $C_6H_2(OCH_3)_3$), 163.5 (*C*-4 $C_6H_2(OCH_3)_3$), 166.6 ppm (*C*-2/*C*-6, $C_6H_2(OCH_3)_3$). ^{29}Si NMR (99.4 MHz, C_6D_6): δ −0.7 ppm. HRMS: *m*/*z* $[M + H]^+$ calcd for $C_{17}H_{29}NO_3Si$: 324.1990; found: 324.1985.

*2-Bromo-4-(4-methoxyphenyl)-4-propyl-4-silacyclohexan-1-one (**5a**).* 5,5-Dibromo-barbituric acid (163 mg, 570 µmol) was added at 20 °C in a single portion to a solution of **1a** (300 mg, 1.14 mmol) in diethyl ether (30 mL), and the resulting mixture was then stirred at 20 °C for 24 h. The liquid phase of the reaction mixture was separated from the precipitate (barbituric acid) by means of a syringe, and the solvent was removed under reduced pressure. Subsequently, diethyl ether (20 mL) and water (20 mL) were added sequentially, the organic

layer was separated, and the aqueous layer was extracted with diethyl ether (3 × 10 mL) and discarded. The combined organic extracts were dried over anhydrous sodium sulfate, the solvent was removed under reduced pressure, and the product was purified by column chromatography on silica gel (40–63 μm, 50 g; eluent, *n*-hexane/dichloromethane (1/1 v/v)) to furnish **5a** in 41% yield as a colorless oil (160 mg, 469 μmol). ^{1}H NMR (500.1 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:3.8) marked with A (major isomer) and B (minor isomer)): δ 0.82−0.87^{A} and 0.95−1.00^{B} (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.90−0.95^{A} and 0.98−1.02^{B} (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.21–1.29^{A} and 1.31–1.38^{B} (m, 2 H; SiC*H*$_2$CH$_2$C), 1.30−1.36^{A} and 1.40−1.47^{B} (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 1.76−1.83^{B}, 1.81−1.88^{A}, 2.02−2.08^{A}, and 2.12−2.19^{B} (m, 2 H; SiC*H*$_2$CH(Br)C), 2.54−2.62^{A}, 2.66−2.73^{B}, 2.79−2.85^{A}, and 2.81−2.86^{B} (m, 2 H; SiCH$_2$C*H*$_2$C), 3.80^{B} and 3.82^{A} (s, 3 H; C$_6$H$_4$OC*H*$_3$), 4.86−4.91^{A} and 5.00−5.05^{B} (m, 1 H; SiCH$_2$C*H*(Br)C), 6.91−6.95^{B} and 6.97−7.00^{A} (m, 2 H; *H*-2/*H*-6, C$_6$H$_4$OCH$_3$), 7.41−7.45^{B} and 7.51−7.54^{A} ppm (m, 2 H; *H*-3/*H*-5, C$_6$H$_4$OCH$_3$). ^{13}C NMR (125.8 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:3.8) marked with A (major isomer) and B (minor isomer)): δ 9.4^{B} and 9.7^{A} (Si*C*H$_2$CH$_2$C), 15.6^{B} and 16.9^{A} (Si*C*H$_2$CH$_2$CH$_3$), 17.4^{A} and 17.7^{B} (SiCH$_2$*C*H$_2$CH$_3$), 18.1^{A} and 18.3^{B} (SiCH$_2$CH$_2$*C*H$_3$), 24.4^{B} and 25.1^{A} (Si*C*H$_2$CH(Br)C), 36.4^{B} and 36.8^{A} (SiCH$_2$*C*H$_2$C), 55.40^{B} and 55.44^{A} (C$_6$H$_4$O*C*H$_3$), 56.3^{B} and 56.5^{A} (SiCH$_2$*C*H(Br)C), 114.2^{B} and 114.5^{A} (*C*-3/*C*-5, C$_6$H$_4$OCH$_3$), 124.7^{A} and 125.1^{B} (*C*-1, C$_6$H$_4$OCH$_3$), 135.69^{B} and 135.70^{A} (*C*-2/*C*-6, C$_6$H$_4$OCH$_3$), 161.5^{B} and 161.6^{A} (*C*-4, C$_6$H$_4$OCH$_3$), 204.2^{B} and 204.3^{A} ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.4 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:3.8) marked with A (major isomer) and B (minor isomer)): δ −6.9^{B} and −5.8^{A} ppm. Anal. Calcd for $C_{15}H_{21}BrO_2Si$: C, 52.78; H, 6.20. Found: C, 52.9; H, 6.0.

*2-Bromo-4-(2,6-dimethoxyphenyl)-4-propyl-4-silacyclohexan-1-one (**5b**).* Compound **5b** was synthesized by using the same procedure as described for the preparation of **5a**, starting from **1b** (1.00 g, 3.42 mmol). The product was purified by column chromatography

on silica gel (40–63 μm, 100 g; eluent, *n*-hexane/ethyl acetate (9/1 v/v)) to furnish **5b** in 53% yield as a colorless oil (675 mg, 1.82 mmol). ^{1}H NMR (500.1 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:1.1) marked with A (major isomer) and B (minor isomer)): δ 0.85−0.90^{A} and 0.92−0.96^{B} (m, 2 H; SiCH_2CH$_2$CH$_3$), 0.88−0.92^{A} and 0.93−0.98^{B} (m, 3 H; SiCH$_2$CH$_2$CH_3), 1.12–1.21^{A} and 1.34–1.43^{B} (m, 2 H; SiCH_2CH$_2$C), 1.27−1.42^{A} and 1.46−1.58^{B} (m, 2 H; SiCH$_2$CH_2CH$_3$), 1.66−1.73^{A}, 1.90−1.98^{B}, 2.21−2.27^{B}, and 2.38−2.44^{A} (m, 2 H; SiCH_2CH(Br)C), 2.57−2.64^{A}, 2.62−2.70^{B}, 2.72−2.79^{A}, and 2.75−2.84^{B} (m, 2 H; SiCH$_2$CH_2C), 3.74^{B} and 3.79^{A} (s, 6 H; C$_6$H$_3$(OCH_3)$_2$), 5.02−5.08^{B} and 5.10−5.16^{A} (m, 1 H; SiCH$_2$C*H*(Br)C), 6.50^{B} and 6.55^{A} (d, $^{3}J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, C$_6$H$_3$(OCH$_3$)$_2$), 7.32^{B} and 7.36^{A} ppm (t, $^{3}J_{HH}$ = 8.3 Hz, 1 H; *H*-4, C$_6$H$_3$(OCH$_3$)$_2$). ^{13}C NMR (125.8 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:1.1) marked with A (major isomer) and B (minor isomer)): δ 12.1^{B} and 12.3^{A} (Si*C*H$_2$CH$_2$C), 16.5^{B} and 17.3^{A} (Si*C*H$_2$CH$_2$CH$_3$), 17.8^{A} and 17.9^{B} (SiCH$_2$*C*H$_2$CH$_3$), 18.1^{A} and 18.2^{B} (SiCH$_2$CH$_2$*C*H$_3$), 27.1^{B} and 27.8^{A} (Si*C*H$_2$CH(Br)C), 37.1^{B} and 37.3^{A} (SiCH$_2$*C*H$_2$C), 55.5^{B} and 55.6^{A} (C$_6$H$_3$(O*C*H$_3$)$_2$), 58.2^{B} and 58.5^{A} (SiCH$_2$*C*H(Br)C), 103.7^{B} and 103.8^{A} (*C*-3/*C*-5, C$_6$H$_3$(OCH$_3$)$_2$), 108.9^{A} and 109.5^{B} (*C*-1, C$_6$H$_3$(OCH$_3$)$_2$), 132.8^{B} and 132.9^{A} (*C*-4, C$_6$H$_3$(OCH$_3$)$_2$), 165.7^{B} and 166.0^{A} (*C*-2/*C*-6, C$_6$H$_3$(OCH$_3$)$_2$), 205.1^{B} and 205.4^{A} ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.4 MHz, CD_2Cl_2; data for two diastereomers (molar ratio 1:1.1) marked with A (major isomer) and B (minor isomer)): δ −7.1^{B} and −6.5^{A} ppm. Anal. Calcd for $C_{16}H_{23}BrO_3Si$: C, 51.75; H, 6.24. Found: C, 51.7; H, 6.4.

*4-Chloro-4-propyl-1,4-azasilepan-7-one (**6**). Method I*. Gaseous hydrogen chloride was passed through a solution of **3a** (70 mg, 252 μmol) in dichloromethane (5 mL) at 20 °C for 15 min, and the reaction mixture was then stirred at 20 °C for 15 min, until the cleavage of the MOP protecting group was complete (monitored by GC/MS analysis). The volatile components (including most of the methoxybenzene) were removed under reduced pressure, and the residue was demonstrated by NMR spectroscopic studies to be a mixture of **6** and

traces of methoxybenzene (see Figures S1−S3 in the Supporting Information). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.89−0.95 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.96−1.01 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.17−1.22 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.20−1.26 (m, 2 H; SiC*H*$_2$CH$_2$C), 1.41−1.50 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.76−2.85 (m, 2 H; SiCH$_2$C*H*$_2$C), 3.65−3.71 (m, 2 H; SiCH$_2$C*H*$_2$N), 9.43 ppm (br. s, 1 H; N*H*). ^{13}C NMR (125.8 MHz, CD_2Cl_2): δ 12.1 (Si*C*H$_2$CH$_2$C), 16.3 (Si*C*H$_2$CH$_2$CH$_3$), 17.3 (SiCH$_2$*C*H$_2$CH$_3$), 17.6 (SiCH$_2$CH$_2$*C*H$_3$), 19.1 (Si*C*H$_2$CH$_2$N), 25.9 (SiCH$_2$*C*H$_2$C), 38.6 (SiCH$_2$*C*H$_2$N), 182.2 ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.4 MHz, CD_2Cl_2): δ 29.9 ppm.

Method II. Gaseous hydrogen chloride was passed through a solution of **3b** (110 mg, 358 µmol) in dichloromethane (10 mL) at 20 °C for 5 min, and the reaction mixture was then stirred at 20 °C for 10 min, until the cleavage of the DMOP protecting group was complete (monitored by GC/MS analysis). The volatile components (including parts of the 1,3-dimethoxybenzene) were removed under reduced pressure, and the residue was demonstrated by NMR spectroscopic studies to be a 1:0.8 mixture of **6** and 1,3-dimethoxybenzene (see Figures S4−S6 in the Supporting Information). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.89−0.94 (m, 2 H; SiC*H*$_2$CH$_2$CH$_3$), 0.96−1.03 (m, 3 H; SiCH$_2$CH$_2$C*H*$_3$), 1.16−1.21 (m, 2 H; SiC*H*$_2$CH$_2$N), 1.19−1.25 (m, 2 H; SiC*H*$_2$CH$_2$C), 1.42−1.52 (m, 2 H; SiCH$_2$C*H*$_2$CH$_3$), 2.76−2.85 (m, 2 H; SiCH$_2$C*H*$_2$C), 3.61−3.68 (m, 2 H; SiCH$_2$C*H*$_2$N), 3.76 (s, 6 H; C$_6$H$_4$(OC*H*$_3$)$_2$), 6.43−6.46 (m, 1 H; *H*-2, C$_6$H$_4$(OCH$_3$)$_2$), 6.47−6.51 (m, 2 H; *H*-4/*H*-6, C$_6$H$_4$(OCH$_3$)$_2$), 7.14−7.19 (m, 1 H; *H*-5, C$_6$H$_4$(OCH$_3$)$_2$), 9.26 ppm (br. s, 1 H; N*H*). ^{13}C NMR (125.8 MHz, CD_2Cl_2): δ 12.1 (Si*C*H$_2$CH$_2$C), 16.3 (Si*C*H$_2$CH$_2$CH$_3$), 17.5 (SiCH$_2$*C*H$_2$CH$_3$), 17.6 (SiCH$_2$CH$_2$*C*H$_3$), 19.2 (Si*C*H$_2$CH$_2$N), 26.0 (SiCH$_2$*C*H$_2$C), 38.3 (SiCH$_2$*C*H$_2$N), 55.5 (C$_6$H$_4$(OC*H*$_3$)$_2$), 100.6 (*C*-2, C$_6$H$_4$(OCH$_3$)$_2$), 106.3 (*C*-4/*C*-6, C$_6$H$_4$(OCH$_3$)$_2$), 130.1 (*C*-5, C$_6$H$_4$(OCH$_3$)$_2$), 161.3 (*C*-1/*C*-3, C$_6$H$_4$(OCH$_3$)$_2$), 181.6 ppm (SiCH$_2$CH$_2$*C*). ^{29}Si NMR (99.4 MHz, CD_2Cl_2): δ 30.1 ppm.

Method III. Gaseous hydrogen chloride was passed through a solution of **3c** (95 mg, 281 µmol) in dichloromethane (7 mL) at 20 °C for 1 min, and the reaction mixture was then stirred at 20 °C for 10 min, until the cleavage of the TMOP protecting group was complete (monitored by GC/MS analysis). The volatile components were removed under reduced pressure, and the residue was demonstrated by NMR spectroscopic studies to be a 1:1 mixture of **6** and 1,3,5-trimethoxybenzene (see Figures S7−S9 in the Supporting Information). ^{1}H NMR (500.1 MHz, CD_2Cl_2): δ 0.88−0.94 (m, 2 H; $SiCH_2CH_2CH_3$), 0.97−1.02 (m, 3 H; $SiCH_2CH_2CH_3$), 1.14−1.19 (m, 2 H; $SiCH_2CH_2N$), 1.17−1.23 (m, 2 H; $SiCH_2CH_2C$), 1.42−1.51 (m, 2 H; $SiCH_2CH_2CH_3$), 2.68−2.80 (m, 2 H; $SiCH_2CH_2C$), 3.56−3.65 (m, 2 H; $SiCH_2CH_2N$), 3.75 (s, 9 H; $C_6H_3(OCH_3)_3$), 6.07 (s, 3 H; $C_6H_3(OCH_3)_3$), 8.42 ppm (br. s, 1 H; N*H*). ^{13}C NMR (125.8 MHz, CD_2Cl_2): δ 12.3 ($SiCH_2CH_2C$), 16.4 ($SiCH_2CH_2CH_3$), 17.7 ($SiCH_2CH_2CH_3$), 18.0 ($SiCH_2CH_2CH_3$), 19.3 ($SiCH_2CH_2N$), 26.6 ($SiCH_2CH_2C$), 38.2 ($SiCH_2CH_2N$), 55.6 ($C_6H_3(OCH_3)_3$), 93.1 (*C*-2/*C*-4/*C*-6, $C_6H_3(OCH_3)_3$), 162.0 ppm (*C*-1/*C*-3/*C*-5, $C_6H_3(OCH_3)_3$), 180.9 ppm ($SiCH_2CH_2C$). ^{29}Si NMR (99.4 MHz, CD_2Cl_2): δ 29.9 ppm.

*Trimethoxypropylsilane (**7**).* This compound was commercially available.

*Dimethoxy(4-methoxyphenyl)propylsilane (**8a**).* A 1 M solution of (4-methoxyphenyl)magnesium bromide in tetrahydrofuran (128 mL, 128 mmol of *p*-$MeOC_6H_4MgBr$) was added dropwise at 20 °C within 3 h to a stirred solution of **7** (20.0 g, 122 mmol) in diethyl ether (200 mL), and stirring was then continued at 20 °C for 16 h. The resulting precipitate was filtered off, washed with diethyl ether (3 × 100 mL), and discarded. The filtrate and wash solutions were combined, the solvents were removed under reduced pressure, and the residue was purified by bulb-to-bulb distillation in vacuo to furnish **8a** in 67% yield as a colorless liquid (19.7 g, 82.0 mmol); bp 99−100 °C/0.3 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.79−0.86 (m, 2 H; $SiCH_2CH_2CH_3$), 0.91−0.99 (m, 3 H; $SiCH_2CH_2CH_3$), 1.35−1.46 (m, 2 H; $SiCH_2CH_2CH_3$), 3.54 (s, 6 H; $SiOCH_3$), 3.81 (s, 3 H; $C_6H_4OCH_3$),

6.90−6.97 (m, 2 H; *H*-2/*H*-6, $C_6H_4OCH_3$), 7.49−7.58 ppm (m, 2 H; *H*-3/*H*-5, $C_6H_4OCH_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 15.1 ($SiCH_2CH_2CH_3$), 16.7 ($SiCH_2CH_2CH_3$), 18.0 ($SiCH_2CH_2CH_3$), 50.7 ($SiOCH_3$), 55.3 ($C_6H_4OCH_3$), 113.9 (*C*-2/*C*-6, $C_6H_4OCH_3$), 124.8 (*C*-1, $C_6H_4OCH_3$), 136.2 (*C*-3/*C*-5, $C_6H_4OCH_3$), 161.7 ppm (*C*-4, $C_6H_4OCH_3$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −15.9 ppm. HRMS: *m*/*z* $[M]^+$ calcd for $C_{12}H_{20}O_3Si$: 240.1182; found: 240.1168.

*(2,6-Dimethoxyphenyl)dimethoxypropylsilane (**8b**).* A 2.5 M solution of *n*-butyllithium in hexanes (53.6 mL, 134 mmol of *n*-BuLi) was added dropwise at 20 °C within 1 h to a stirred mixture of 1,3-dimethoxybenzene (16.8 g, 122 mmol), *N*,*N*,*N*`,*N*`-tetramethylenediamine (TMEDA; 15.6 g, 134 mmol), and *n*-pentane (60 mL). The resulting suspension of DMOP−Li was stirred at 20 °C for 16 h and then added to a stirred solution of **7** (20.0 g, 122 mmol) in diethyl ether (80 mL) at 20 °C within 1 h, and the reaction mixture was stirred at 20 °C for a further 16 h. The resulting precipitate was filtered off, washed with diethyl ether (3 × 100 mL), and discarded. The filtrate and wash solutions were combined, the solvents were removed under reduced pressure, and the residue was purified by bulb-to-bulb distillation in vacuo to furnish **8b** in 58% yield as a colorless liquid (19.1 g, 70.6 mmol); bp 108−109 °C/0.2 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.78−0.88 (m, 2 H; $SiCH_2CH_2CH_3$), 0.92−0.99 (m, 3 H; $SiCH_2CH_2CH_3$), 1.36−1.46 (m, 2 H; $SiCH_2CH_2CH_3$), 3.52 (s, 6 H; $SiOCH_3$), 3.78 (s, 6 H; $C_6H_3(OCH_3)_2$), 6.54 (d, $^3J_{HH}$ = 8.2 Hz, 2 H; *H*-3/*H*-5, $C_6H_3(OCH_3)_2$), 7.34 ppm (t, $^3J_{HH}$ = 8.2 Hz, 1 H; *H*-4, $C_6H_3(OCH_3)_2$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 16.7 ($SiCH_2CH_2CH_3$), 18.2 ($SiCH_2CH_2CH_3$), 18.3 ($SiCH_2CH_2CH_3$), 50.9 ($SiOCH_3$), 55.7 ($C_6H_3(OCH_3)_2$), 103.8 (*C*-3/*C*-5, $C_6H_3(OCH_3)_2$), 109.4 (*C*-1, $C_6H_3(OCH_3)_2$), 133.0 (*C*-4, $C_6H_3(OCH_3)_2$), 166.2 ppm (*C*-2/*C*-6, $C_6H_3(OCH_3)_2$). ^{29}Si NMR (99.4 MHz, CD_2Cl_2): δ −16.7 ppm. HRMS: *m*/*z* $[M]^+$ calcd for $C_{13}H_{22}O_4Si$: 270.1287; found: 270.1264.

*Dimethoxypropyl(2,4,6-trimethoxyphenyl)silane (**8c**).* A 2.5 M solution of *n*-butyllithium in hexanes (62.4 mL, 156 mmol of *n*-BuLi) was added dropwise at 20 °C within 1 h to a stirred mixture of 1,3,5-trimethoxybenzene (25.0 g, 149 mmol), TMEDA (18.1 g, 156 mmol), and *n*-pentane (150 mL). The resulting suspension of TMOP−Li was stirred at 20 °C for 16 h and then added to a stirred solution of **7** (23.2 g, 141 mmol) in diethyl ether (150 mL) at 20 °C within 1 h, and the reaction mixture was stirred at 20 °C for a further 16 h. The resulting precipitate was filtered off, washed with diethyl ether (3 × 100 mL), and discarded. The filtrate and wash solutions were combined, the solvents were removed under reduced pressure, and the residue was purified by bulb-to-bulb distillation in vacuo to furnish **8c** in 72% yield as a colorless liquid (30.3 g, 101 mmol); bp 121−122 °C/0.2 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.75−0.84 (m, 2 H; Si$CH_2$$CH_2$$CH_3$), 0.91−0.96 (m, 3 H; Si$CH_2$$CH_2$$CH_3$), 1.33−1.44 (m, 2 H; Si$CH_2$$CH_2$$CH_3$), 3.49 (s, 6 H; Si$OCH_3$), 3.76 (s, 6 H; *o*-$OCH_3$, $C_6H_2(OCH_3)_3$), 3.82 (s, 3 H; *p*-OCH_3, $C_6H_2(OCH_3)_3$), 6.09 ppm (s, 2 H; *H*-3/*H*-5, $C_6H_2(OCH_3)_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 16.8 (Si$CH_2$$CH_2$$CH_3$), 18.3 (Si$CH_2$$CH_2$$CH_3$), 18.4 (Si$CH_2$$CH_2$$CH_3$), 50.8 (Si$OCH_3$), 55.6 (*p*-$OCH_3$, $C_6H_2(OCH_3)_3$), 55.7 (*o*-OCH_3, $C_6H_2(OCH_3)_3$), 90.6 (*C*-3/*C*-5, $C_6H_2(OCH_3)_3$), 101.1 (*C*-1, $C_6H_2(OCH_3)_3$), 164.5 (*C*-4 $C_6H_2(OCH_3)_3$), 167.3 ppm (*C*-2/*C*-6, $C_6H_2(OCH_3)_3$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −16.3 ppm. HRMS: *m*/*z* $[M]^+$ calcd for $C_{14}H_{24}O_5Si$: 300.1393; found: 300.1400.

*(4-Methoxyphenyl)propyldivinylsilane (**9a**).* A 1.9 M solution of vinylmagnesium chloride in tetrahydrofuran (77.0 mL, 146 mmol of CH_2=CHMgCl) was added dropwise at 20 °C within 2 h to a stirred solution of **8a** (14.0 g, 58.2 mmol) in diethyl ether (200 mL), and the reaction mixture was then stirred at 20 °C for 16 h. Subsequently, diethyl ether (200 mL) and water (200 mL) were added sequentially, the organic layer was separated, and the aqueous layer was extracted with diethyl ether (3 × 100 mL) and discarded. The combined organic extracts were dried over anhydrous sodium sulfate, the solvents were removed under reduced

pressure, and the residue was purified by bulb-to-bulb distillation in vacuo to furnish **9a** in 81% yield as a colorless liquid (11.0 g, 47.3 mmol); bp 94−96 °C/0.2 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.91−0.95 (m, 2 H; SiCH_2CH$_2$CH$_3$), 0.95−1.00 (m, 3 H; SiCH$_2$CH$_2$CH_3), 1.38−1.47 (m, 2 H; SiCH$_2$CH_2CH$_3$), 3.80 (s, 3 H; C$_6$H$_4$OCH_3), 5.75 (δ_A), 6.12 (δ_M), and 6.28 (δ_X) (CH_X=C$H_A H_M$, $^{3}J_{AX}$ = 20.3 Hz, $^{2}J_{AM}$ = 3.9 Hz, $^{3}J_{MX}$ = 14.7 Hz, 6 H), 6.91 (m, 2 H; *H*-2/*H*-6, C$_6$H$_4$OCH$_3$), 7.44 ppm (m, 2 H; *H*-3/*H*-5, C$_6$H$_4$OCH$_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 15.9 (Si*C*H$_2$CH$_2$CH$_3$), 17.1 (SiCH$_2$*C*H$_2$CH$_3$), 18.5 (SiCH$_2$CH$_2$*C*H$_3$), 55.3 (C$_6$H$_4$O*C*H$_3$), 113.9 (*C*-2/*C*-6, C$_6$H$_4$OCH$_3$), 126.6 (*C*-1, C$_6$H$_4$OCH$_3$), 134.7 (SiCH=*C*H$_2$), 135.7 (*C*-3/*C*-5, C$_6$H$_4$OCH$_3$), 136.6 (Si*C*H=CH$_2$), 161.1 ppm (*C*-4, C$_6$H$_4$OCH$_3$). ^{29}Si NMR (99.4 MHz, CD_2Cl_2): δ −17.4 ppm. HRMS: *m*/*z* $[M]^+$ calcd for $C_{14}H_{20}OSi$: 232.1283; found: 232.1271.

*(2,6-Dimethoxyphenyl)propyldivinylsilane (**9b**).* Compound **9b** was synthesized by using the same procedure as described for the preparation of **9a**, starting from **8b** (5.00 g, 18.5 mmol). The product was purified by bulb-to-bulb distillation in vacuo to furnish **9b** in 88% yield as a colorless liquid (4.27 g, 16.3 mmol); bp 98−100 °C/0.1 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.93−0.97 (m, 2 H; SiCH_2CH$_2$CH$_3$), 0.98−1.02 (m, 3 H; SiCH$_2$CH$_2$CH_3), 1.33−1.43 (m, 2 H; SiCH$_2$CH_2CH$_3$), 3.72 (s, 6 H; C$_6$H$_3$(OCH_3)$_2$), 5.67 (δ_A), 5.96 (δ_M), and 6.42 (δ_X) (CH_X=C$H_A H_M$, $^{3}J_{AX}$ = 20.4 Hz, $^{2}J_{AM}$ = 3.9 Hz, $^{3}J_{MX}$ = 14.6 Hz, 6 H), 6.51 (d, $^{3}J_{HH}$ = 8.3 Hz, 2 H; *H*-3/*H*-5, C$_6$H$_3$(OCH$_3$)$_2$), 7.30 ppm (t, $^{3}J_{HH}$ = 8.3 Hz, 1 H; *H*-4, C$_6$H$_3$(OCH$_3$)$_2$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 16.9 (Si*C*H$_2$CH$_2$CH$_3$), 18.1 (SiCH$_2$*C*H$_2$CH$_3$), 18.6 (SiCH$_2$CH$_2$*C*H$_3$), 55.5 (C$_6$H$_3$(O*C*H$_3$)$_2$), 104.1 (*C*-3/*C*-5, C$_6$H$_3$(OCH$_3$)$_2$), 111.2 (*C*-1, C$_6$H$_3$(OCH$_3$)$_2$), 130.9 (SiCH=*C*H$_2$), 132.3 (*C*-4, C$_6$H$_3$(OCH$_3$)$_2$), 138.3 (Si*C*H=CH$_2$), 166.0 ppm (*C*-2/*C*-6, C$_6$H$_3$(OCH$_3$)$_2$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −20.5 ppm. HRMS: *m*/*z* $[M]^+$ calcd for $C_{15}H_{22}O_2Si$: 262.1389; found: 262.1389.

*Propyl(2,4,6-trimethoxyphenyl)divinylsilane (**9c**).* Compound **9c** was synthesized by using the same procedure as described for the preparation of **9a**, starting from **8c** (23.0 g, 76.6 mmol). The product was purified by bulb-to-bulb distillation in vacuo to furnish **9c** in 80% yield as a colorless liquid (17.9 g, 61.2 mmol); bp. 120−121 °C/0.3 mbar. ^{1}H NMR (500.0 MHz, CD_2Cl_2): δ 0.92−0.96 (m, 2 H; Si$CH_2CH_2CH_3$), 0.94−0.98 (m, 3 H; $SiCH_2CH_2CH_3$), 1.30−1.40 (m, 2 H; $SiCH_2CH_2CH_3$), 3.70 (s, 6 H; *o*-OCH_3, $C_6H_2(OCH_3)_3$), 3.80 (s, 3 H; *p*-OCH_3, $C_6H_2(OCH_3)_3$), 5.65 (δ_A), 5.94 (δ_M), and 6.39 (δ_X) ($CH_X{=}CH_AH_M$, $^{3}J_{AX}$ = 20.4 Hz, $^{2}J_{AM}$ = 4.0 Hz, $^{3}J_{MX}$ = 14.6 Hz, 6 H), 6.08 ppm (s, 2 H; *H*-3/*H*-5, $C_6H_2(OCH_3)_3$). ^{13}C NMR (125.7 MHz, CD_2Cl_2): δ 17.1 ($SiCH_2CH_2CH_3$), 18.1 ($SiCH_2CH_2CH_3$), 18.6 ($SiCH_2CH_2CH_3$), 55.47 (*p*-OCH_3, $C_6H_2(OCH_3)_3$), 55.53 (*o*-OCH_3, $C_6H_2(OCH_3)_3$), 91.0 (*C*-3/*C*-5, $C_6H_2(OCH_3)_3$), 102.5 (*C*-1, $C_6H_2(OCH_3)_3$), 130.7 ($SiCH{=}CH_2$), 138.6 ($SiCH{=}CH_2$), 164.1 (*C*-4 $C_6H_2(OCH_3)_3$), 166.9 ppm (*C*-2/*C*-6, $C_6H_2(OCH_3)_3$). ^{29}Si NMR (99.3 MHz, CD_2Cl_2): δ −20.2 ppm. HRMS: *m*/*z* $[M + H]^+$ calcd for $C_{16}H_{24}O_3Si$: 293.1573, found: 293.1558.

Crystal Structure Analyses. Suitable single crystals of **3a** and **3b** were obtained directly from the respective syntheses. The crystals were mounted in inert oil (perfluoropolyalkyl ether) on a glass fiber and then transferred to the cold nitrogen gas stream of the diffractometer (graphite-monochromated $Mo_{K\alpha}$ radiation, λ = 0.71073 Å). The structures were solved by direct methods (SHELXS-2013) and refined by full-matrix least-squares methods on F^2 for all unique reflections (SHELXL-2013).[11] SHELXLE was used as refinement GUI.[12] A riding model was employed in the refinement of the CH hydrogen atoms. CCDC-1052862 (**3a**) and CCDC-1052863 (**3b**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

■ ASSOCIATED CONTENT

Supporting Information

Data for the crystal structure analyses of compounds **3a** and **3b** (Table S1); ^{1}H, ^{13}C, and ^{29}Si NMR spectra of the mixtures **6**/H−MOP, **6**/H−DMOP, and **6**/H−TMOP (Figures S1−S9); ^{1}H, ^{13}C, and ^{29}Si NMR spectra of compounds **1a**–**1c**, **2a**–**2c**, **3a**–**3c**, **4a**–**4c**, **5a**, **5b**, **8a**–**8c**, and **9a**–**9c** (Figures S10−S69). This material is available free of charge via the Internet at http://pubs.acs.org.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: r.tacke@uni-wuerzburg.de

Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) Recent reviews dealing with silicon-based drugs: (a) Meanwell, N. A. *J. Med. Chem.* **2011**, *54*, 2529–2591. (b) Franz, A. K.; Wilson, S. O. *J. Med. Chem.* **2013**, *56*, 388–405. (c) Sieburth, S. McN. *Top. Med. Chem.*, doi: 10.1007/7355_2014_80; (d) Tacke, R.; Dörrich, S. *Top. Med. Chem.*, doi: 10.1007/7355_2014_55.

(2) A recent publication dealing with silicon-based drugs: Geyer, M.; Wellner, E.; Jurva, U.; Saloman, S.; Armstrong, D.; Tacke, R. *ChemMedChem* **2015**, *10*, 911–924.

(3) Fischer, M.; Tacke, R. *Organometallics* **2013**, *32*, 7181–7185; and references cited therein.

(4) Fischer, M.; Burschka, C.; Tacke, R. *Organometallics* **2014**, *33*, 1020–1029.

(5) (a) Popp, F.; Nätscher, J. B.; Daiss, J. O.; Burschka, C.; Tacke, R. *Organometallics* **2007**, *26*, 6014–6028. (b) Laskowski, N.; Reis, E.-M.; Kötzner, L.; Baus, J. A.; Burschka, C.; Tacke, R. *Organometallics* **2013**, *32*, 3269–3278; and references cited therein.

(6) (a) Carlson, B. A.; Brown, H. C. *J. Am. Chem. Soc.* **1973**, *95*, 6876–6877. (b) Carlson, B. A.; Katz, J.-J.; Brown, H. C. *J. Organomet. Chem.* **1974**, *67*, C39–C42. (c) Soderquist, J. A.; Hassner, A. *J. Org. Chem.* **1983**, *48*, 1801–1810. (d) Soderquist, J. A.; Shiau, F.-Y.; Lemesh, R. A. *J. Org. Chem.* **1984**, *49*, 2565–2569. (e) Soderquist, J. A.; Negron, A. *J. Org. Chem.* **1987**, *52*, 3441–3442. (f) Soderquist, J. A.; Negron, A. *J. Org. Chem.* **1989**, *54*, 2462–2464. (g) Damour, D.; Renaudon, A.; Mignani, S. *Synlett* **1995**, 111–112.

(7) Grundke, G.; Keese, W.; Rimpler, M. *Chem. Ber.* **1985**, *118*, 4288–4291.

(8) (a) Tacke, R.; Heinrich, T.; Bertermann, R.; Burschka, C.; Hamacher, A.; Kassack, M. U. *Organometallics* **2004**, *23*, 4468–4477. (b) Tacke, R.; Nguyen, B.; Burschka, C.; Lippert, W. P.; Hamacher, A.; Urban, C.; Kassack, M. U. *Organometallics* **2010**, *29*, 1652–1660.

(9) Geyer, M.; Wellner, E.; Fjellström, O.; Tacke, R.; unpublished results.

(10) Wang, J.; Ma, C.; Wu, Y.; Lamb, R. A.; Pinto, L. H.; DeGrado, W. F. *J. Am. Chem. Soc.* **2011**, *133*, 13844–13847.

(11) Sheldrick, G. M. *Acta Crystallogr., Sect. A* **2008**, *64*, 112–122.

(12) Hübschle, C. B.; Sheldrick, G. M.; Dittrich. B. *J. Appl. Crystallogr.* **2011**, *44*, 1281–1284.