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A novel one-pot procedure for the synthesis of stable dioxadiazastannepines and dioxadiazasilepines

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Abstract—A novel synthetic approach to seven-membered silicon- and tin-containing heterocycles has been developed. 5,6-Diaryl-1,3,4,7,2-dioxadiazastannepines **3a**–**l** and 5,6-diaryl-1,3,4,7,2-dioxadiazasilepines **4a**–**l** were prepared in one pot from vicinal dioximes **1a**–**d** and diorganodichlorostannanes and diorganodichlorosilanes via dianion intermediate **2** in good yields.

The development of clean procedures for the preparation of heterocyclic compounds is a major challenge of modern heterocyclic chemistry in view of the environmental, practical and hence economic issues that the need for extensive purification of complex reaction mixtures raises. Monocyclic medium ring heterocycles are an extremely important class of compounds, which occur in a range of natural and unnatural products. Cyclocondensation reactions are recognized as worthwhile synthetic methods for preparing heterocyclic compounds.[1] Increasing interest has been paid for several years to the chemistry of heterocycles containing tin and silicon due to their unique properties and remarkable potential biological activity.[2,3] Monocyclic eight-membered silicon-[4] or tin-containing[5] heterocycles have been investigated; these new monocyclic diorganosilanes are prepared by condensation reactions.[6] Furthermore, benzostannepines[7] have been synthesized via a tin hydride intermediate. A variety of silaheterocycles have been obtained by intramolecular carbene or carbenoid pathways from silyldiazoacetic esters.[8] Seven-membered rings containing five heteroatoms (N, O and Sn or N, O and Si) are very rare. Our aim is to broaden the range of useful heterocycles, which may provide easy access to synthetic intermediates and therapeutic agents. In our continuing studies[9–12] on the synthesis of new heterocyclic ring systems, we herein describe a very simple and direct route to dioxadiazastannepines and dioxadiazasilepines, from easily available dioximes.

Since keto-oximes are useful building blocks for the preparation of *O*,*N*-heterocycles, we firstly employed vicinal dioximes **1a**–**d** as starting materials. The oxime group is amphiprotic with a slightly basic nitrogen and a mildly acidic hydroxyl group. Dianions[13] have become increasingly popular as strategic tools. Our goal is predominantly to prepare heteroatom-based dianions as synthons for a variety of new heterocycles. Following the route depicted in Scheme 1, dianions **2** were prepared directly from **1** by deprotonation with sodium hydride, and then trapped with suitable dielectrophiles, that is, diorganodichlorostannanes and diorganodichlorosilanes leading to the formation of novel seven-membered heterocycles **3**[14] and **4**.[15] These compounds were characterized on the basis of satisfactory elemental analyses and spectroscopic data.[16]

The success of the above cyclization reactions prompted us to expand this methodology to the preparation of different dioxadiazastannepines and dioxadiazasilepines. Spectral analysis showed IR bands for C=N, Sn–O and Si–O in the expected regions. The methyl groups attached to tin had proton signals in the region 0.96–1.12 ppm, whereas in the silicon heterocycles, the methyls appeared in the region 0.28–0.42 ppm. The signals for the *n*-butyl protons were visible in the expected regions for both tin and silicon compounds. In addition, the ^{13}C NMR spectra supported the assigned structures. Mass spectroscopic data of the compounds established their monomeric nature (Table 1).

Keywords: Dioxadiazastannepines; Dioxadiazasilepines; Dioximes; Dianion; Heterocycles.
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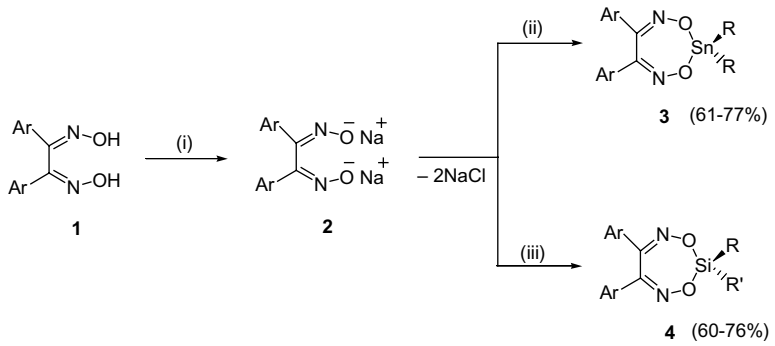

Scheme 1. Reagents: (i) 2NaH/THF; (ii) R_2SnCl_2; (iii) $RR'SiCl_2$.

Table 1. Synthesis of dioxadiazastannepines (**3a–l**) and dioxadiazasilepines (**4a–l**)

Entry	Ar	R	R′	Products[a,b]	Yield of **3** (%)[c]	Mp of **3** (°C)	Yield of **4** (%)[c]	Mp of **4** (°C)
1	C_6H_5	CH_3	CH_3	**3a**, **4a**	76	242	62	273
2	*p*-ClC_6H_4	CH_3	CH_3	**3b**, **4b**	64	200	70	165
3	*p*-$CH_3C_6H_4$	CH_3	CH_3	**3c**, **4c**	68	214	67	198
4	*p*-$CH_3OC_6H_4$	CH_3	CH_3	**3d**, **4d**	61	220	65	215
5	C_6H_5	*n*-Bu	*n*-Bu	**3e**	65	213	—	—
6	*p*-ClC_6H_4	*n*-Bu	*n*-Bu	**3f**	72	195	—	—
7	*p*-$CH_3C_6H_4$	*n*-Bu	*n*-Bu	**3g**	66	205	—	—
8	*p*-$CH_3OC_6H_4$	*n*-Bu	*n*-Bu	**3h**	70	221	—	—
9	C_6H_5	C_6H_5	C_6H_5	**3i**, **4e**	77	230	69	160
10	*p*-ClC_6H_4	C_6H_5	C_6H_5	**3j**, **4f**	76	193	60	130
11	*p*-$CH_3C_6H_4$	C_6H_5	C_6H_5	**3k**, **4g**	62	212	73	158
12	*p*-$CH_3OC_6H_4$	C_6H_5	C_6H_5	**3l**, **4h**	69	207	63	175
13	C_6H_5	CH_3	Cl	**4i**	—	—	73	238
14	*p*-ClC_6H_4	CH_3	Cl	**4j**	—	—	61	195
15	*p*-$CH_3C_6H_4$	CH_3	Cl	**4k**	—	—	64	206
16	*p*-$CH_3OC_6H_4$	CH_3	Cl	**4l**	—	—	76	227

[a] All reactions were carried out according to the typical procedures.[14,15]
[b] All new compounds gave satisfactory (±0.4% of the theoretical values) elemental analyses.
[c] Isolated yields.

A short and facile synthesis of new stable dioxadiazastannepines and dioxadiazasilepines is presented. This procedure occurs through the generation of a nucleophilic dianion, which is intermolecularly trapped with dielectrophiles to give the novel heterocycles. Compounds **1b–d** were prepared following literature methods.[17,18] All reactions were carried out under a dry, oxygen-free nitrogen atmosphere.

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Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.tetlet.2004.11.031.

References and notes

1. Tanabe, Y.; Nagaosa, M.; Nishii, Y. *Heterocycles* **1995**, *41*, 2033.
2. (a) Gielen, M.; Boualam, M.; Biesemans, M.; Mahieu, B.; Willem, R. *Heterocycles* **1992**, *34*, 549; (b) Boualam, M.; Willem, R.; Biesemans, M.; Mahieu, B.; Gielen, M. *Heteroatom Chem.* **1991**, *2*, 447; (c) Gielen, M. *Appl. Organometal. Chem.* **2002**, *16*, 481.
3. Hoshino, O.; Hirayama, T. *Heterocycles* **1997**, *44*, 509.
4. (a) Corey, J. Y.; Janoski, H. M.; Vermount, D. F.; Paton, J. P.; Chang, V. H. T. *J. Organomet. Chem.* **1980**, *194*, 15; (b) Larsen, W.; Corey, J. Y. *J. Am. Chem. Soc.* **1977**, *99*, 1740.
5. (a) Klebe, G.; Hensen, K.; Fuess, H. *Chem. Ber.* **1983**, *116*, 3125; (b) Macharashvili, A. A.; Shklover, V. E.; Struchkov, Y.-T.; Oleneva, G. I.; Kramarova, E. P.; Shipov, A. G.; Baukov, Y.-I. *J. Chem. Soc., Chem. Commun.* **1988**, 683; (c) Wang, J. *Prog. Nat. Sci.* **1998**, *8*, 180; (d) *Chem. Abstr.* **1998**, *128*, 308507h.
6. (a) Chandrasekaran, A.; Day, R. O.; Holmes, R. R. *Organometallics* **1996**, *15*, 3182; (b) Crisp, G. T.; Bubner, T. P. *Tetrahedron* **1997**, *53*, 11881.
7. Sashida, H.; Kuroda, A.; Tsuchiya, T. *Chem. Commun.* **1998**, 767.
8. Kroke, E.; Weidenbruch, M. In *Organosilicon Chemistry II From Molecules to Materials*; Auner, N., Weis, J., Eds.; Wiley-VCH: Weinheim, Germany, 1996; pp 95–100.
9. (a) Singh, M. S.; Mehrotra, K. N.; Mishra, G. *Phosphorus Sulfur Silicon* **1991**, *63*, 177; (b) Singh, M. S.; Rao, R. J. *Phosphorus Sulfur Silicon* **1992**, *68*, 115.

10. (a) Singh, M. S. *Phosphorus Sulfur Silicon* **1995**, *106*, 187; (b) Singh, M. S.; Singh, A. K. *Synth. Commun.* **2000**, *30*, 53.
11. (a) Singh, M. S.; Singh, A. K. *Heterocycles* **2000**, *53*, 851; (b) Singh, M. S.; Singh, A. K. *Indian J. Chem.* **2000**, *39B*, 551; (c) Singh, M. S.; Pandey, G. *Synth. Commun.* **2000**, *30*, 3589.
12. (a) Singh, M. S.; Singh, A. K. *Indian J. Chem.* **2002**, *41B*, 1507; (b) Singh, M. S.; Singh, A. K. *Synthesis* **2004**, 837.
13. (a) Petranani, N.; Yonashiro, M. *Synthesis* **1982**, 521; (b) von Rague Schleyer, P. *Pure Appl. Chem.* **1983**, *55*, 355; (c) Grovenstein, E., Jr. *Stud. Org. Chem.* **1987**, *5*, 175.
14. Typical procedure for the preparation of 2,2-dimethyl-5,6-diphenyl-1,3,4,7,2-dioxadiazastannepine **3a**: A solution of benzildioxime (**1a**; 864 mg, 3.60 mmol) in dry THF (25 mL) was added dropwise to a solution of sodium hydride (173 mg, 7.20 mmol) in 30 mL of dry THF at room temperature. The solution became whitish yellow after 30 min and was then stirred under reflux for 2 h. The solution became pinkish light yellow and was allowed to attain room temperature. Dimethyldichlorostannane (792 mg, 3.60 mmol) was slowly added dropwise with a syringe. The solution became pinkish white, and the reaction mixture was stirred for an additional 2 h at room temperature. TLC confirmed completion of the reaction. After filtration of the reaction mixture, the solvent was evaporated in vacuo, and the residue was subjected to column chromatography (hexane/ethyl acetate, 8:1) to yield the product.
15. Typical procedure for the preparation of 2,2-dimethyl-5,6-diphenyl-1,3,4,7,2-dioxadiazasilepine **4a**: A procedure analogous to the preparation of **3a** was used. Benzildioxime (720 mg, 3 mmol) in 25 mL of dry THF and 144 mg (6 mmol) of sodium hydride in 30 mL of THF were used. Dimethyldichlorosilane (387 mg, 3 mmol) was added dropwise via a static-pressure dropping funnel at room temperature. Removal of the solvent under reduced pressure yielded the product, which was purified by column chromatography with *n*-hexane/ethyl acetate (6:1) to give the title compound.
16. Analytical and spectroscopic data for selected compounds: **3a**: IR (KBr): 1616, 1120, 525 cm^{-1}; ^1H NMR ($CDCl_3$, 270 MHz): δ 7.63–6.78 (br, m, 10H, H_{arom}), 0.96 (s, 6H, $SnMe_2$); ^{13}C NMR ($CDCl_3$, 67.84 MHz): δ 12.4, 118.3, 121.7, 127.9, 132.4, 142.7, 154.3; *m/z* (%): 388 (M^+, 19), 372, 357, 222, 165, 103, 77, 15; Anal. Calcd for $C_{16}H_{16}N_2O_2Sn$: C, 49.61; H, 4.13%. Found: C, 49.72; H, 4.27%. **4a**: IR (KBr): 1612, 1245, 956 cm^{-1}; ^1H NMR ($CDCl_3$, 270 MHz): δ 7.63–6.78 (br, m, 10H, H_{arom}), 0.32 (s, 6H, $SiMe_2$); ^{13}C NMR ($CDCl_3$, 67.84 MHz): δ −3.46 ($SiMe_2$), 114.6, 120.4, 126.8, 128.2, 143.8, 152.2; *m/z* (%): 296 (M^+, 14), 281, 266, 222, 103, 77, 74, 60, 15; Anal. Calcd for $C_{16}H_{16}N_2O_2Si$: C, 64.86; H, 5.41%. Found: C, 64.64; H, 5.76%.
17. Corson, B. B.; McAllister, R. W. *J. Am. Chem. Soc.* **1929**, *51*, 2822.
18. Dreos, R.; Tauzher, G.; Trendafilova, D. H.; Nardin, G.; Randaccio, L. *Inorg. Chem.* **1996**, *35*, 2715.