

Available online at www.sciencedirect.com



Inorganic Chemistry Communications 6 (2003) 1344-1346

Inorganic Chemistry Communications

www.elsevier.com/locate/inoche

## Silyl group mediated linkage of closo-C<sub>2</sub>B<sub>10</sub>-cage to *nido*-C<sub>2</sub>B<sub>4</sub>-carborane: synthesis of the novel carborane ligand, 1-R-2-[5'-(SiMe<sub>2</sub>CH<sub>2</sub>)-2',3'-(SiMe<sub>3</sub>)<sub>2</sub>-2',3'-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub> (R = Me, Ph)

Yinghuai Zhu<sup>a,b,1</sup>, John A. Maguire<sup>b</sup>, Narayan S. Hosmane<sup>a,\*</sup>

<sup>a</sup> Department of Chemistry and Biochemistry, Northern Illinois University, DeKalb, IL 60115, USA <sup>b</sup> Department of Chemistry, Southern Methodist University, Dallas, TX 75275, USA

> Received 30 May 2003; accepted 7 July 2003 Published online: 11 September 2003

## Abstract

The reaction of the sodium salt of the monoanion, *nido*-[2,3-(Si(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>-2,3-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]<sup>-</sup>, with (chloromethyl)dimethylchlorosilane in a 1:1 molar ratio produced the B<sub>(cage)</sub>-substituted cluster, *nido*-5-ClCH<sub>2</sub>Si(CH<sub>3</sub>)<sub>2</sub>-2,3-(Si(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>-2,3-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub> (1), in 81% yield. This product (1) was reacted further with the lithium salt of [*closo*-1-R-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub>]<sup>-</sup> monoanion (R = Me, Ph) to give the novel linked and mixed C<sub>2</sub>B<sub>4</sub>/C<sub>2</sub>B<sub>10</sub> carborane species, 1-Me-2-[5'-SiMe<sub>2</sub>CH<sub>2</sub>-2',3'-(SiMe<sub>3</sub>)<sub>2</sub>-2',3'-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub> (2), 1-Ph-2-[5'-SiMe<sub>2</sub>CH<sub>2</sub>-2',3'-(SiMe<sub>3</sub>)<sub>2</sub>-2',3'-(C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub> (2), 1-Ph-2-[5'-SiMe<sub>2</sub>CH<sub>2</sub>-2',3'-(SiMe<sub>3</sub>)<sub>2</sub>-2',3'-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub> (3), in yields of 76% and 81%, respectively. © 2003 Elsevier B.V. All rights reserved.

The study of the coordination chemistry of carborane clusters derived from the 1-R-2-R'-1,2-C<sub>2</sub>B<sub>10</sub>H<sub>10</sub> and 2-R-*n*-R'-2,*n*-C<sub>2</sub>B<sub>4</sub>H<sub>6</sub> (n = 3, 4; R, R' = H or a C<sub>(cage)</sub> derivative) cage systems have most often been studied separately [1–7]. Since each cage system offers its own attractions, the targeted syntheses of specific linked-carborane compounds containing both large and small coordinating cages capable of having charges ranging from -1 to -4 could lead to a series of ligands having unique properties. As a first step in the development of such compounds, we report herein the synthesis and characterization of the novel linked and mixed C<sub>2</sub>B<sub>4</sub>/C<sub>2</sub>B<sub>10</sub> carborane cages that are envisioned to be the precursors to the desired ligands for a number of unusual metallacarborane complexes.

The reaction of the sodium salt of the [nido-2,3- $(Si(CH_3)_3)_2-2,3-C_2B_4H_5]^-$  anion [8,9] with (chloromethyl)dimethylchlorosilane, in a 1:1 molar ratio in diethyl ether, followed by extraction and purification, produced a new unique- $B_{(cage)}$ -substituted small cage carborane, nido-5-ClCH<sub>2</sub>Si(CH<sub>3</sub>)<sub>2</sub>-2,3-(Si(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>-2,3- $C_2B_4H_5$  (1) in 81% yield (Scheme 1) [10]. The reaction of 1 with the lithium salt of the  $[closo-1-R-1,2-C_2B_{10}H_{10}]^{-1}$ anion (R = Me, Ph) in 1:1 molar ratio in diethyl ether, followed by extraction and purification, produced the novel silvl-bridged, mixed carborane species, 1-R-2- $[5'-SiMe_2CH_2-2', 3'-(SiMe_3)_2-2', 3'-C_2B_4H_5]-1, 2-C_2B_{10}H_{10}$ [R = Me (2) and Ph (3)], in yields of 76% and 81%, respectively [11,12]. Unfortunately, compounds 2 and 3 are viscous liquids, so they could not be structurally characterized by X-ray diffraction. However, their elemental analyses and spectroscopic data are all consistent with the structures shown for these compounds in Scheme 1. The <sup>1</sup>H NMR spectra of all the three compounds show resonances in the  $\delta = -1.82$  to -1.20 ppm range, which are characteristic for the B-H-B bridge hydrogens of the smaller cage [8,9]. In addition, resonances for the hydrogens in the various alkyl and/or aryl

<sup>\*</sup>Corresponding author. Tel.: +1-815-753-3556; fax: +1-815-753-4802.

*E-mail addresses:* jmaguire@mail.smu.edu (J.A. Maguire), nhos-mane@niu.edu (N.S. Hosmane).

<sup>&</sup>lt;sup>1</sup> Present address: Institute of Chemical and Engineering Sciences, Block 28, # 02-08, Ayer Rajah Crescent, Singapore 139959, Singapore.



groups (CH<sub>3</sub>, C<sub>6</sub>H<sub>5</sub>, Si–CH<sub>3</sub> and CH<sub>2</sub>) were all found in their expected regions of the <sup>1</sup>H NMR spectra. The <sup>13</sup>C NMR spectra of compounds 2 and 3 confirm the presence of both the  $C_2B_4$  and  $C_2B_{10}$ -cage carbons, as well as those in the different substituent groups and are all consistent with the proposed structures. The  ${}^{11}B{H}$ NMR spectrum of 1 shows three resonances with a 1:2:1 peak area ratio. The broad singlet at  $\delta = 14.87$  ppm is due to the unique boron [B(5) in the usual numbering system], while the doublets at  $\delta = 0.91$  and  $\delta = -50.21$ ppm are due to the basal and apical BHs, respectively. This spectrum is quite typical for the nido-5-R-2,3-(SiMe<sub>3</sub>)<sub>2</sub>-2,3-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub> carboranes [13]. As expected, these peaks are still retained essentially in their same positions of the  ${}^{11}B{H}$  NMR spectra of 2 and 3, in addition to those observed for the  $C_2B_{10}$ -cages [14].

The synthesis shown in Scheme 1 is a general one that could be used to couple different carborane polyhedra to produce a series of interesting and potentially useful *ansa*-ligands. Such work is currently underway in our laboratories.

## Acknowledgements

This work was supported by grants from the National Science Foundation (CHE-9988045 and CHE-0241319), the donors of the Petroleum Research Fund, administered by the American Chemical Society, The Robert A. Welch Foundation (N-1322 to J.A.M.) and Northern Illinois University through a Presidential Research Professorship. The Forschungspreis der Alexander von Humboldt-Stiftung and the nominating Professors, Dr. Herbert W. Roesky of Universität Göttingen and Dr. Wolfgang Kaim of Universität Stuttgart, are also hereby gratefully acknowledged.

## References

 A.K. Saxena, J.A. Maguire, N.S. Hosmane, Chem. Rev. 97 (1997) 2421–2462.

- [2] C.K. Broder, A.E. Goeta, A.K. Howard, A.K. Hughes, A.L. Johnson, J.M. Malget, K. Wade, J. Chem. Soc., Dalton Trans. (2000) 3526–3533.
- [3] R. Uhrhammer, Y.-X. Su, D.C. Swenson, R.F. Jordan, Inorg. Chem. 33 (1994) 4398–4402.
- [4] X. Bei, C. Kreuder, D.C. Swenson, R.F. Jordan, V.G. Young Jr., Organometallics 17 (1998) 1085–1091.
- [5] Y.-X. Su, C.E. Reck, I.A. Guzei, R.F. Jordan, Organometallics 19 (2000) 4858–4861.
- [6] X. Bei, V.G. Young Jr., R.F. Jordan, Organometallics 20 (2001) 355–358.
- [7] Z. Xie, Z. Liu, K. Chiu, F. Xue, T.C.W. Mak, Organometallics 16 (1997) 2460–2464.
- [8] N.S. Hosmane, N.N. Sirmokadam, M.N. Mollenhauer, J. Organomet. Chem. 279 (1985) 359–371.
- [9] N.S. Hosmane, A.K. Saxena, R.D. Barreto, H. Zhang, J.A. Maguire, L. Jai, Y. Wang, A.R. Oki, K.V. Grover, S.J. Whitten, K. Dawson, M.A. Tolle, U. Siriwardane, T. Demisse, J.S. Fagner, Organometallics 12 (1993) 3001–3014.
- [10] All syntheses were performed under an argon atmosphere using a combination of glove box and high-vacuum techniques. Synthesis of (1): A solution of 0.75 g (3.41 mmol) of 2,3(Si(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>-2,3-C<sub>2</sub>B<sub>4</sub>H<sub>6</sub> in 40 ml of dry THF was slowly added over a period of 10 min to a suspension of 0.2 g (7.67 mmol) of NaH in the same solvent at -78 °C. After addition, the mixture was slowly warmed to room temperature and held at that temperature for  $\sim 1$  day. After that time, the reaction mixture was filtered and the clear filtrate was added to a solution of 0.5 ml (3.67 mmol) (chloromethyl)dimethylchlorosilane dissolved in 30 ml of dry THF at -78 °C and kept at the temperature for 2 h. The system was then warmed to room temperature and stirred for 2 days. After the reaction, the solvent was removed under reduced pressure to give a pale yellow residue. A pure pale yellow oily product, identified as nido-5-ClCH<sub>2</sub>Si(CH<sub>3</sub>)<sub>2</sub>-2,3-(Si(CH<sub>3</sub>)<sub>3</sub>)<sub>2</sub>-2,3-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub> (1), was obtained in 81% yield after extraction of the residue with 50 ml of pentane and drying in a vacuum. Compound 1 was purified by silica gel column chromatography (eluted with pentane). Elemental Anal. Calcd. for 1: C, 40.49; H, 9.58. Found: C, 40.73; H, 9.77%. The spectroscopic data for 1: <sup>1</sup>H NMR (C<sub>6</sub>D<sub>6</sub>, relative to external Me<sub>4</sub>Si)  $\delta$  -1.40 to -1.18 [br, 2H, B-H-B], 0.24 [s, 6H, B-Si-(CH<sub>3</sub>)<sub>2</sub>], 0.42 [s, 18H, 2 C-Si-(CH<sub>3</sub>)<sub>3</sub>], 2.68 [s, 2H,Cl-CH<sub>2</sub>]; <sup>11</sup>B NMR (C<sub>6</sub>D<sub>6</sub>, relative to external BF<sub>3</sub> · OEt<sub>2</sub>)  $\delta$  -50.21 [d, apical BH, <sup>1</sup>J(<sup>11</sup>B-<sup>1</sup>H) = 175 Hz], 0.91 [d, basal BH,  ${}^{1}J({}^{11}B{}^{-1}H) = 139$  Hz], 14.87 [s(br), basal BSi]; <sup>13</sup>C NMR (C<sub>6</sub>D<sub>6</sub>, relative to external Me<sub>4</sub>Si)  $\delta$  -3.30 [q, Si-(CH<sub>3</sub>)<sub>2</sub>,  ${}^{1}J({}^{13}C{}^{-1}H) = 120$  Hz], 2.01 [q, Si-(CH<sub>3</sub>)<sub>3</sub>,  ${}^{1}J({}^{13}C{}^{-1}H) = 120$  Hz], 29.68 [t, Cl-CH<sub>2</sub>,  ${}^{1}J({}^{13}C-{}^{1}H) = 87$  Hz], 141.704 [s (br), cage-Csubstituted]; IR (cm<sup>-1</sup>, KBr cell) 2955 (s,s), 2894 (s,s), 2864 (s,m) [v(C-H)], 2571 (s,s) [v(B-H)], 1404 (s,m), 1306 (sh)  $[\delta(CH)_{asym}]$ , 1250 (vs,s) [ $\delta$ (CH)<sub>sym</sub>], 1091 (s,s), 1066 (s,s), 938 (s,s), 840 (vs, br)  $[\rho(CH)]$ , 799 (s,s), 758 (s,s), 687 (m,s), 630 (m,s), 479 (m,s).

[11] Synthesis of 2: A 1.50 ml (2.40 mmol) solution of n-BuLi (1.6 M in hexanes) was added, over a period of 20 min, to a solution of 0.3 g (1.90 mmol) of 1-Me-1,2  $C_2B_{10}H_{11}$  in 30 ml dry diethyl ether at -78 °C. After addition, the mixture was allowed to warm to room temperature and reacted at that temperature for 4 h. The solvent was then removed under reduced pressure and the residue was washed with dry pentane to eliminate any unreacted n-BuLi. A 40 ml aliquot of diethyl ether was transferred via high-vacuum line to a flask containing the pure lithium salt of 1-methyl-orthocarborane to obtain a clear solution that was added over a 30 min interval at -78 °C to a solution of 0.62 (1.90 mmol) 5- $ClCH_2Si(CH_3)_2-2,3-(Si(CH_3)_3)_2-2,3-C_2B_4H_5$  (1) in 40 ml diethyl ether. The reaction mixture was stirred at -78 °C for 2 h and then was slowly warmed to room temperature. After continued stirring at room temperature for 2 days, the solvent was removed under reduced pressure to obtain a slightly yellow, oily residue. This crude product was extracted with 40 ml of dry pentane, dried in vacuum and then purified by silica gel column chromatography (eluted with pentane) to obtain 1-Me-2-[5'-SiMe2CH2-2',3'- $(SiMe_3)_2 - 2', 3' - C_2B_4H_5] - 1, 2 - C_2B_{10}H_{10}$  (2) as a pale yellow sticky oily product in 76% yield. The product could be converted into a waxy solid when held at 0 °C under an argon atmosphere. Elemental Anal. Calcd for 2: C, 37.52; H, 9.89. Found: C, 37.75; H, 9.87%. The spectroscopic data for 2: <sup>1</sup>H NMR ( $C_6D_6$ , relative to external Me<sub>4</sub>Si)  $\delta$  -1.82 to -1.58 [br, 2H, B-H-B], 0.22 [s, 6H, B-Si-(CH<sub>3</sub>)<sub>2</sub>], 0.42 [s, 18H, 2 C-Si-(CH<sub>3</sub>)<sub>3</sub>], 1.53 [s, 3H,  $C_{(large\ cage)} - CH_3], 2.65\ [s,\ 2H, C_{(large\ cage)} - CH_2 - Si];\ ^{11}B\ NMR\ (C_6D_6,$ relative to external BF<sub>3</sub>·OEt<sub>2</sub>)  $\delta$  -50.39 [d, apical B-H(small cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 176$  Hz], -10.33 [s, apical B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 158$  Hz], -8.91 [s, basal B-H(large cage), {}^{1}J({}^{11}B-{}^{1}H) = 158 Hz], -8.91 [s, basal B-H(large cage), {}^{1}J({}^{11}B-{}^{1}H) = 158 Hz], -8.91 [s, basal B-H(large cage), {}^{1}J({}^{11}B-{}^{1}H) = 158  $^{1}$ H) = 153 Hz], -5.57 [s, basal B-H(large cage),  $^{1}J(^{11}B-^{1}H) = 153$ Hz], -4.61 [s, basal B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 148$  Hz], 0.98 [s, overlapping basal B-H(large cage) and basal B(small cage)], 14.57 [s(br), basal B-Si(small cage)]; <sup>13</sup>C NMR (C<sub>6</sub>D<sub>6</sub>, relative to external Me<sub>4</sub>Si)  $\delta$  -3.10 [q, Si-(CH<sub>3</sub>)<sub>2</sub>, <sup>1</sup>J(<sup>13</sup>C<sup>-1</sup>H) = 123 Hz], 2.04 [q, Si-(CH<sub>3</sub>)<sub>3</sub>,  ${}^{1}J({}^{13}C-{}^{1}H) = 119$  Hz], 25.55 [q, CH<sub>3</sub>(large cage),  ${}^{1}J({}^{13}C-{}^{1}H) = 132$  Hz], 29.23 [t, CH<sub>2</sub>(large cage), 20  $^{1}$ H) = 141 Hz], 69.68 [s, large cage-C-substituted], 75.61 [s, large cage-C-substituted], 143.98 [s (br), small cage-C-substituted]; IR (cm<sup>-1</sup>, KBr cell) 2955 (s,br), 2894 (s,s), 2587 (vs,br) [v(B-H)large and small cage], 2279 (m,s), 1947 (m,s), 1537 (m,s), 1501 (m,s),

1460 (m,s), 1409 (s,s), 1393 (s,s), 1312 (w,s) [ $\delta$ (CH)<sub>asym</sub>], 1250 (vs,s) [ $\delta$  (CH)<sub>sym</sub>], 117 (s,s), 1076 (s,s), 1050 (s,s), 1004 (s,s), 927 (s,s), 846 (vs,br) [ $\rho$ (CH)], 758 (s,s), 682 (s,s), 636 (s,s), 502 (s,s), 461 (m,s).

- [12] Synthesis of 3: In a procedure identical to that used in the synthesis and purification of 2 above, except that the lithium salt of phenyl-ortho-carborane was substituted for its methyl analogue, 1-Ph-2-[5'-SiMe<sub>2</sub>CH<sub>2</sub>-2',3'-(SiMe<sub>3</sub>)<sub>2</sub>-2',3'-C<sub>2</sub>B<sub>4</sub>H<sub>5</sub>]-1,2  $C_2B_{10}H_{10}$  (3) was isolated in 81% yield as a sticky pale yellow substance. Elemental Anal. Calcd. for 3: C, 44.73; H, 9.09. Found: C, 44.41; H, 8.97%. The spectroscopic data for 3: <sup>1</sup>H NMR ( $C_6D_6$ , relative to external Me<sub>4</sub>Si)  $\delta$  -1.80 to -1.76 [br, 2H, B-H-B], -0.07 [s, 6H, B-Si-(CH<sub>3</sub>)<sub>2</sub>], 0.43 [s, 18H, 2 C-Si-(CH<sub>3</sub>)<sub>3</sub>], 2.40 [s, 2H, C<sub>(large cage)</sub>-CH<sub>2</sub>-Si], 6.88-7.42 [m, 5H, C<sub>6</sub>H<sub>5</sub>]; <sup>11</sup>B NMR (C<sub>6</sub>D<sub>6</sub>, relative to external BF<sub>3</sub>·OEt<sub>2</sub>)  $\delta$  -50.33 [d, apical BH(small cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 178$  Hz], -11.02 [d, apical B-H(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = unresolved]$ , -8.53 [sh, basal BH(large cage), presup $1J(^{11}B-^{1}H) = 153$  Hz], -3.29 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage),  ${}^{1}J({}^{11}B-{}^{1}H) = 162$  Hz], -2.36 [s, basal BH(large cage), -2.36  $^{1}$ H) = 150 Hz], 1.10 [s, overlapping basal BH(large cage) and basal BH(small cage)], 14.63 [s(br), apical B-Si(small cage)]; <sup>13</sup>C NMR  $(C_6D_6, \text{ relative to external Me}_4\text{Si}) \delta - 3.65 [q, Si-(CH_3)_2, {}^1J({}^{13}\text{C}-$ <sup>1</sup>H) = 152 Hz], 2.02 [q, Si–(CH<sub>3</sub>)<sub>3</sub>, <sup>1</sup>J(<sup>13</sup>C–<sup>1</sup>H) = 119 Hz], 29.03 [t, CH<sub>2</sub> (large cage),  ${}^{1}J({}^{13}C{}^{-1}H) = 142$  Hz], 74.63 [s, large cage-Csubstituted], 83.82 [s, large cage-C-substituted], 127.32-132.98 [m,  $C_6H_5$ ], 143.86 [s (br), small cage-C-substituted]; IR (cm<sup>-1</sup>, KBr cell) 2955 (s,br), 2894 (s,s), 2592 (vs,br) [v(B-H)<sub>large and small cage</sub>], 2274 (m,s), 2264 (s,s), 1947 (m,s), 1537 (m, s), 1501 (m,s), 1454 (m,s), 1408 (s,s), 1393 (s,s), 1322 (s,s) [ $\delta$ (CH)<sub>asym</sub>], 1250 (vs,s)  $[\delta(CH)_{svm}]$ , 1086 (s,s), 1045 (w,s), 958(m,s), 927 (s,s), 886 (s,s), 835 (vs,br) [ $\rho$ (CH)], 753 (s,s), 692 (s,s), 518 (s,s), 636 (s,s), 497 (s,s).
- [13] J.A. Maguire, J.-Q. Wang, C. Zheng, C. Li, N.S. Hosmane, Inorg. Chim. Acta C 334 (2002) 91–104.
- [14] (a) Y. Zhu, K. Vyakaranam, J.A. Maguire, W. Quintana, F. Teixidor, C. Vinas, N.S. Hosmane, Inorg. Chem. Commun. 4 (2001) 486–489;
  - (b) Y. Zhu, J.A. Maguire, N.S. Hosmane, Inorg. Chem. Commun. 5 (2002) 296–299;
  - (c) J. Wang, Y. Zhu, S.-J. Li, C. Zheng, J.A. Maguire, N.S. Hosmane, J. Organomet. Chem. 680 (2003) 172–181.