

Palladium-catalyzed reaction of 1-aza-5-germa-5-organobicyclo[3.3.3]undecane with aryl bromide

Masanori Kosugi ^{a,*}, Tadatoshi Tanji ^a, Yukio Tanaka ^a, Atsushi Yoshida ^a, Keigo Fugami ^a,
Masayuki Kameyama ^b, Toshihiko Migita ^c

^a Department of Chemistry, Gunma University, Kiryu, Gunma 376, Japan

^b Oyama National College of Technology, Oyama, Tochigi 323, Japan

^c School of High-Technology for Human Welfare, Tokai University, Numazu, Shizuoka 410-03, Japan

Received 5 July 1995; in revised form 19 July 1995

Abstract

Successive treatment of triallylamine with zirconocene chloride hydride and germanium tetrachloride affords 1-aza-5-germa-5-chlorobicyclo[3.3.3]undecane, which is converted to the 5-organo derivatives by the reaction with Grignard or lithium reagents. The organo groups showed higher reactivities toward Stille-type coupling than the corresponding organotributylgermanes.

Keywords: Germanium; Cross-coupling; Palladium; Catalysis

Organostannane is one of the useful synthetic reagents for carbon–carbon bond formation. Transition-metal-catalyzed cross-coupling reaction of organostannane with organic halides or triflates is now widely utilized [1]. As for the organosilicon compounds, fluoride-ion-mediated palladium-catalyzed reactions have been recently developed [2]. Relatively few papers, however, have appeared for the palladium-catalyzed reactions of organogermanes [3]. To our knowledge, only the cross-coupling reaction of trimethylvinylgermane with aryl tetrafluoroborate is known [4]. From the observation of the silicon chemistry, the usual tetracoordinated organogermanium species are considered to be less reactive in the presence of a palladium catalyst. Therefore we intended to prepare 1-aza-5-germa-5-organobicyclo[3.3.3]undecane, expecting that reactivity of the organo group is enhanced by the transannular coordination of nitrogen to germanium. We now report the preparation of 1-aza-5-germa-5-organobicyclo[3.3.3]undecane and the palladium-catalyzed reaction with aryl bromides. As the transmetalation of zirconium to germanium is known [5], we used a similar method to synthesize the corresponding tin compound reported by Vedejs et al. [6].

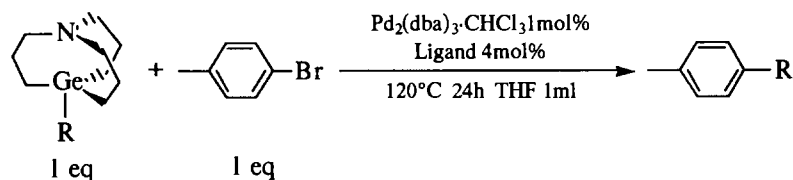
Thus hydrozirconation of triallylamine, followed by the transmetalation with germanium tetrachloride gave a novel 1-aza-5-germa-5-chlorobicyclo[3.3.3]undecane with 89% yield [7]. By the reaction with the corresponding Grignard or lithium reagents, it could be converted into the corresponding 5-organo compounds (yields; butyl, 74%; allyl, 82%; phenyl, 97%; vinyl, 98%; 1-ethoxyvinyl, 86%; phenylethynyl, 11%) [8].

First of all, the corresponding tributylgermanes were prepared and their palladium-catalyzed reaction with *p*-bromotoluene was investigated as a comparison with the reaction of the bicyclo germanium compounds. Most of the reactions did not give the cross-coupling products at all, except for the reaction of tributylvinylgermane, which afforded *p*-methylstyrene with 60% yield. The result can be explained from a similar palladium-catalyzed reaction of trimethylvinylsilane with aryl iodide [9].

Palladium-catalyzed reaction of 1-aza-5-germa-5-organobicyclo[3.3.3]undecanes thus prepared with aryl bromide was carried out as follows: a mixture of the germane (1 mmol) and the halide (1 mmol) in the presence of tris(dibenzylideneacetone)dipalladium chloroform (0.01 mmol) plus the phosphine (0.04 mmol) and tetrahydrofuran (1 ml) was sealed in vacuo in a glass ampoule and was heated in a thermobath at 120°C for 24 h. The product was analyzed by gas–liquid

* Corresponding author.

Table 1
Pd-catalyzed reaction of the bicyclogermane with *p*-bromotoluene



Entry	R	Ligand	GLC yield ^a (%)
1	Butyl	PPh(<i>o</i> -tol) ₂	8
2	Allyl ^b	PPh ₃	88 (77)
3	Phenyl	P(<i>o</i> -tol) ₃	95 (85)
4	Vinyl	P(<i>o</i> -tol) ₃	82
5	1-Ethoxyvinyl ^c	PPh(<i>o</i> -tol) ₂	59
6	Phenylethynyl	PPh(<i>o</i> -tol) ₂	67

^a Isolated yield given in parentheses

^b Bromobenzene was used as the aryl halide.

^c The product was *p*-methylacetophenone.

chromatography (GLC) with *n*-dodecane as an internal standard. The product was isolated by silica gel chromatography, after aqueous work-up of the reaction mixture, followed by extraction with ether and dried over sodium sulfate. The results are shown in Table 1. As expected, cross-coupling products were obtained with moderate to good yield except for the butylation. It is interesting to note that generally the phosphine having the *o*-tolyl group gave products with a good yield. However, the allylation was the only exception, i.e. the use of triphenylphosphine gave a superior yield to that of tri(*o*-tolyl)phosphine. At present the reason for this is not known. Use of tri(2-furyl)phosphine or triphenylarsine, which are good ligands of palladium for the Stille-type coupling, [10] showed similar results when used triphenylphosphine.

Thus, we synthesized 1-aza-5-germa-5-organo-bicyclo[3.3.3]undecanes. In these compounds, a significant enhancement of reactivities of the organo groups toward Stille-type coupling was observed, in compari-

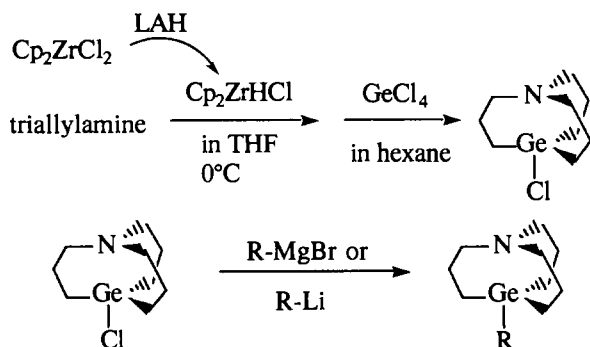
son with that of the corresponding organotributylgermanes, presumably owing to the transannular coordination of nitrogen to germanium, although the reactivity was not as great as that of the corresponding tributyltin compounds. Further work is in progress.

Acknowledgment

This work was supported by Grants-in-Aid for Scientific Research on Priority Area of Reactive Organometallics 05236101 and 05236102 from the Ministry of Education, Science and Culture, Japan.

References and notes

- [1] J.K. Stille, *Angew. Chem., Int. Edn. Engl.*; 25 (1986) 508; T.N. Mitchell, *Synthesis*, (1992) 803, and references cited therein.
- [2] Y. Hatanaka and T. Hiyama, *Synlett*, (1991) 845, and references cited therein.
- [3] K. Yamamoto, A. Hayashi, S. Suzuki and J. Tsuji, *Organometallics*, 6 (1987) 974; T. Tsumuraya and W. Ando, *Organometallics*, 8 (1989) 2286; 9 (1990) 869; T. Hayashi, H. Yamashita, T. Sakakura, Y. Uchamaru and M. Tanaka, *Chem. Lett.*, (1991) 245; N.P. Reddy, T. Hayashi and M. Tanaka, *Chem. Lett.*, (1991) 677; K. Mochida, C. Hodota, H. Yamashita and M. Tanaka, *Chem. Lett.*, (1992) 1635; N. Chatani, N. Horiuchi and T. Hanafusa, *J. Org. Chem.*, 55 (1990) 3393; T.N. Mitchell, U. Schneider and B. Frohling, *J. Organomet. Chem.*, 384 (1990) C53.
- [4] K. Ikenaga, S. Matsumoto, K. Kikukawa and T. Matsuda, *Chem. Lett.*, (1990) 185.
- [5] A. Kanj, P. Meunier, B. Gautheron, J. Dubac and J.-C. Daran, *J. Organomet. Chem.*, 454 (1993) 51.
- [6] E. Vedejs, A.R. Haight and W.O. Moss, *J. Am. Chem. Soc.*, 114 (1992) 6556.
- [7] Colorless needles; melting point, 181.5–184.5°C. ¹H NMR (CDCl₃, 200 MHz) δ = 1.40 (dd, *J* = 7.0, 6.6 Hz, 6H, -CH₂-Ge-), 1.78 (dddd, *J* = 7.0, 6.6, 6.2, 5.7 Hz, 6H, -CH₂-), 2.55



R = butyl, allyl, phenyl, vinyl, 1-ethoxyvinyl, phenylethynyl

(dd, $J = 6.2, 5.8$ Hz, 6H, $-\text{CH}_2-\text{N}-$). Gas chromatography–mass spectroscopy (70 eV): m/e 250 (M^+), 214 ($\text{M}^+ - \text{Cl}$), 109, 84, 42. Anal. Found: C, 43.41; H, 7.05; N, 5.51. $\text{C}_9\text{H}_{18}\text{NClGe}$ calc.: C, 43.54; H, 7.31; N, 5.64%.

- 8] Oily materials were obtained after usual work-up. Purified using gel permeation chromatography and showed satisfactory ^1H NMR spectra. For example, for butyl, ^1H NMR: δ 0.30–0.38 (m, 2H), 0.62 (dd, $J = 6.6, 6.4$ Hz, 6H), 0.81–0.89 (m, 3H), 1.20–1.28 (m, 4H), 1.46–1.58 (m, 6H), 2.40 (dd, $J = 5.9, 5.6$ Hz, 6H) ppm. For allyl, ^1H NMR: δ 0.69 (dd, $J = 6.6, 6.4$ Hz, 6H), 1.35 (dt, $J = 8.4, 1.4$ Hz, 2H), 1.47–1.59 (m, 6H), 2.40

(dd, $J = 6.0, 5.6$ Hz, 6H), 4.61 (dm, $J = 9.9$ Hz, 1H), 4.68 (dm, $J = 16.9$ Hz, 1H), 5.86 (ddt, $J = 16.9, 9.9, 8.5$ Hz, 1H) ppm. For phenyl, ^1H NMR: $\delta = 0.94$ (dd, $J = 6.6, 6.4$ Hz, 6H), 1.57–1.70 (m, 6H), 2.47 (dd, $J = 5.9, 5.7$ Hz, 6H), 7.18–7.30 (m, 3H), 7.39–7.47 (m, 2H) ppm. For vinyl, ^1H NMR: $\delta = 0.75$ (dd, $J = 6.6, 6.5$ Hz, 6H), 1.49–1.62 (m, 6H), 2.42 (dd, $J = 5.9, 5.7$ Hz, 6H), 5.42 (dd, $J = 20.2, 4.0$ Hz, 1H), 5.76 (dd, $J = 13.9, 4.0$ Hz, 1H), 6.32 (dd, $J = 20.2, 13.9$ Hz, 1H).

[9] A. Hallberg and C. Westerlund, *Chem. Lett.*, (1982) 1993.

[10] V. Farina and B. Krishnan, *J. Am. Chem. Soc.*, 113 (1991) 9585.