Pergamon

Tetrahedron Letters, Vol. 35, No. 32, pp. 5853-5856, 1994
Elsevier Science Ltd
Printed in Great Britain
0040-4039/94 $7.00+0.00

0040-4039(94)01170-2

Synthesis of Carbo- and Heterocyclic Compounds by Radical-Initiated Cyclizations of Propargylsilanes

Dieter Schinzer*[a], Peter G. Jones[b], Kerstin Obierey[a]

[a]Institut für Organische Chemie der Technischen Universität Braunschweig, Hagenring 30, D-38106 Braunschweig, Germany

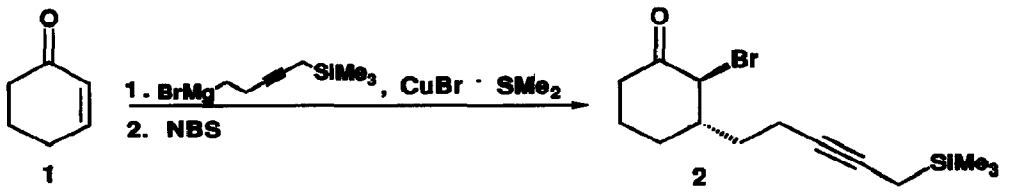
[b]Institut für Anorganische und Analytische Chemie der Technischen Universität Braunschweig, Hagenring 30, D-38106 Braunschweig, Germany

Abstract: Propargylic silanes of type **2,4,9,11**, and **13** undergo smooth cyclization in refluxing benzene and in the presence of AIBN and tributyltin hydride. Ring closure of carbocycles and also of 5- and 6-membered O-heterocyclic rings is achieved in high chemical yields.

Radical cyclizations have proved to be valuable synthetic methods of forming cyclic or polycyclic frameworks.[1,2]

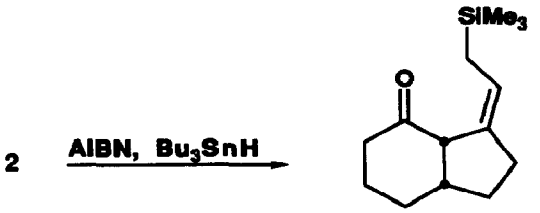
In this letter we wish to report a novel method of constructing either carbo- or heterocyclic skeletons by a radical cyclization - initiated by AIBN in the presence of tributyltin hydride - of propargylic silanes.

Ketones of type **2** or **4** can be easily obtained by a tandem reaction of the copper-catalyzed addition of a functionalized Grignard reagent to cyclohexenone **1** and *in situ* quenching with NBS.[3]

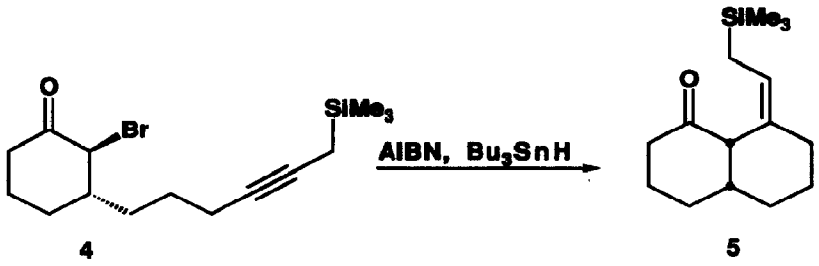


1 **2**

The carbocyclic ketones **2** and **4** can be directly cyclized with AIBN and tributyltin hydride to give the desired bicyclic ketones as a ca. 6 : 1 ratio of diastereomers of the resulting allyl silanes **3** (34%), and **5** (50%); the Z-isomers predominate.[3]



3

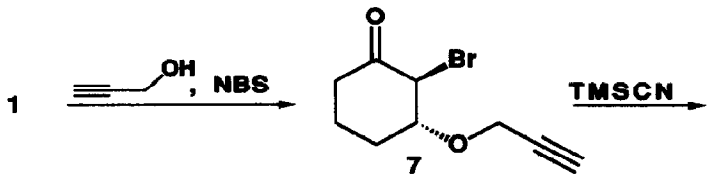


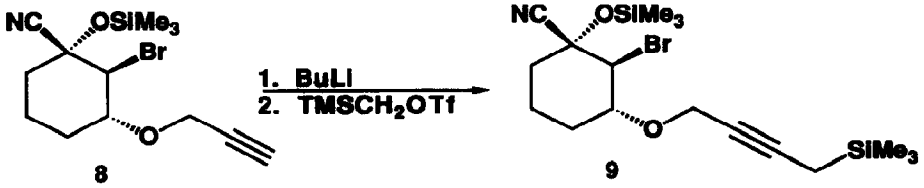
4 5

These bicyclic compounds contain the synthetically useful allylsilane as a result of the radical cyclization of the propargyl silane. Especially exocyclic allylic silanes are not easy obtained because only cyclic ketones can be used in these particular Wittig reactions.[4]

Allylsilanes can be regioselectively transformed in the presence of electrophiles to a wide variety of functionalized compounds which demonstrates the high potential of these compounds in organic synthesis.[5-8]

The next systems we examined were O-heterocyclic compounds of type **10** and **12**. The precursors **9** and **11** for this operation can be prepared by one-pot procedures with the enones in the presence of the unsaturated alcohols and NBS.[9]





However, in order to synthesize the desired precursors for the heterocyclic series we had to protect the carbonyl group as silylated cyanohydrins **9** and **11**.[10] These compounds cyclized smoothly under standard conditions in quantitative yield to give the desired O-heterocycles **10** (>98%) and **12** (>98%) both in a ratio of diastereomers of about 4 : 1, again favoring the Z-isomer of the allylic silane.[3] The structure of compound **10** (Z-isomer) has been confirmed by X-ray analysis.[11,12]

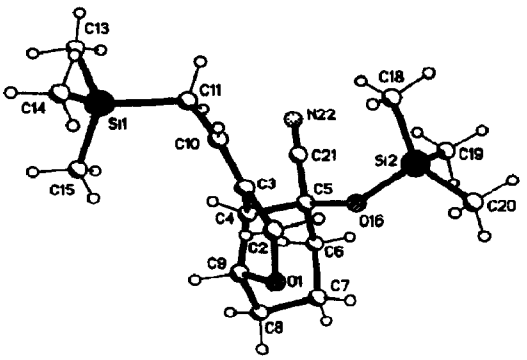
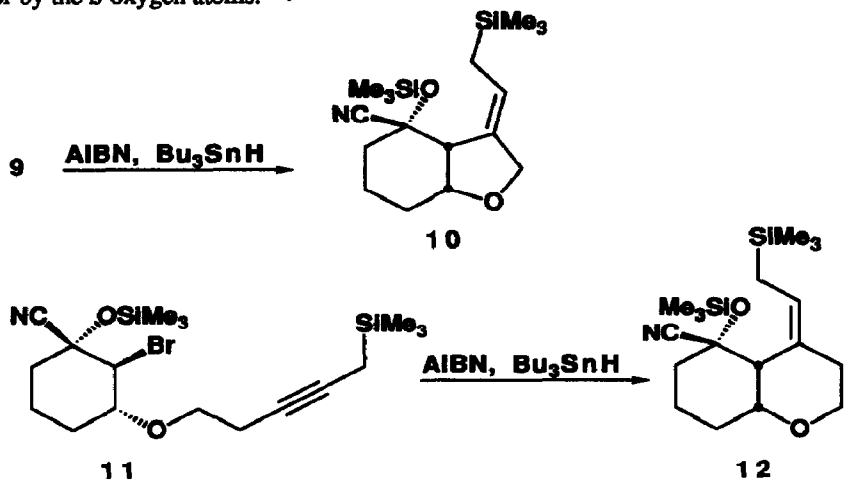
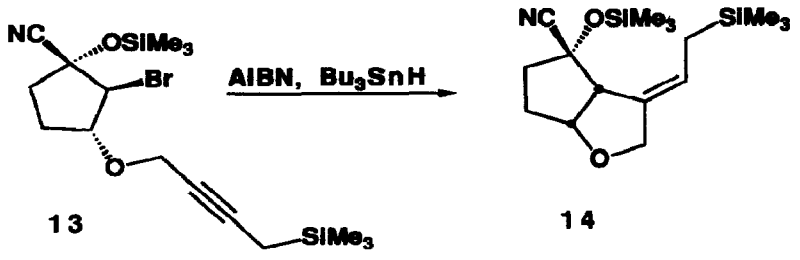


Figure. Molecular structure of **10** in the crystal

This dramatic influence of the silylated cyanohydrin could be a result of ß-stabilization of the radical by the nitrile group or by the ß-oxygen atoms.[13,14]



Finally we have tested compound **13** in order to form the synthetically useful oxo-bicyclo-octane system **14**, which we obtained in 40% yield, again favoring the Z-isomer of the allyl silane in a ratio of about 4 : 1.[3,15]



In summary, we have demonstrated that radical cyclizations of propargyl silanes are a powerful method of constructing carbo- and hetero-bicyclic systems that contain the synthetically useful allylic silanes. The allylsilanes obtained can be transformed to a wide variety of systems by known procedures. The extension of this method to other heterocycles and ring sizes is currently underway in our laboratories.

Acknowledgment. This work was supported by the the Fonds der Chemischen Industrie. We are indebted to the Schering AG, Berlin, for generous gifts of chemicals. Mr. A. Weinkauf provided technical aasistance in the X-ray structure determination.

References and Notes

1. Giese, B. *"Radicals in Organic Synthesis. Formation of Carbon-Carbon Bonds"*. Pergamon Press, Oxford **1986**.
2. Stork, G.; Mook, R. *J. Am. Chem. Soc.* **1983**, *105*, 3720.
3. All new compounds gave spectral and analytical spectrometric data consistent with the assigned structures.
4. Fleming, I.; Paterson, I. *Synthesis* **1979**, 447.
5. Fleming, I.; Dunogues, J. *Organic Reactions* **1989**, *37*, 57.
6. Sakurai, H. *Pure and Appl. Chem.* **1982**, *54*, 1.
7. Majetich, G. in *Organic Synthesis, Theory and Application:* T. Hudlicky, Ed., Jai Press, Inc. Greenwich, CT, **1989**, 173.
8. Schinzer, D. *Synthesis* **1988**, 263.
9. Dulcere, J. P.; Rodriguez, J.; Santelli, M. *Tetrahedron Lett.* **1987**, *28*, 2009.
10. Groutas, W. C.; Felker, D. *Synthesis* **1980**, 861.
11. **Standard procedure:** To a solution of compound **9** (157mg, 0.39mmol) in 25ml of benzene was added a trace of AIBN and the mixture was heated to reflux. A solution of tributyl tin hydride (134mg, 0.46mmol) was added over 1 h with a syringe pump and the mixture was refluxed for an additional 3 h. The mixture was poured into a saturated solution of NaF, and the organic layer was dried over $MgSO_4$. The crude product was flash chromatographed with pentane/diethyl ether (9:1) to yield 97mg of compound **10** (Z-isomer) and 34mg of compound **10** (E-isomer). Spectroscopic data of compound **10** (Z-isomer): ^{1}H-NMR ($CDCl_3$), (400 MHz): 0.01 (s, 9 H); 0.19 (s, 9 H); 1.33 (m, 2 H); 1.63 (m, 2 H); 1.88 (m, 2 H); 2.096 (m, 2 H); 2.73 (dd, 1 H, J = 2.73 Hz, J = 23.62 Hz); 4.01-3.89 (m, 1 H), 4.25 (m, 2 H); 5.57 (dtr, 1H, J = 8.66 Hz, J = 14.63 Hz). ^{13}C-NMR ($CDCl_3$), (100 MHz): 136.35; 123.27; 119.89; 76.38; 72.50; 70.98; 51.80; 38.17; 27.08; 20.49; 14.78; 0.97; -1.82.
12. Crystal data for **10**: triclinic, $P\bar{1}$, a = 1151.2(3), b = 1385.5(3), c = 1403.3(3) pm, α = 70.83(2), β = 88.84(2), γ = 77.40(2) ^{o} (at -130 ^{o}C), Z = 2. The structure was refined on F^2 (program SHELXL-93, G.M. Sheldrick, Univ. of Göttingen) to $wR(F^2)$ 0.130, conventional $R(F)$ 0.046 for 7251 reflections to $2\Theta_{max}$ 50^o (Mo $K\alpha$). Full details of the structure determination have been deposited at the Fachinformationszentrum Karlsruhe, Gesellschaft für Wissenschaftlich-technische Information mbH, D-76344 Eggenstein-Leopoldshafen, Germany. Any request for this material should quote a full literature citation and the reference number CSD-400906.
13. Beckwith, A. L. J. *Chem. Soc. Rev.* **1993**, 143.
14. Korth, H. G.; Sustmann, R.; Giese, B.; Rückert, B.; Gröninger, K. S. *Chem. Ber.* **1990**, *123*, 1891.
15. RajanBabu, T. V. *J. Org. Chem.* **1988**, *53*, 4522.

(*Received in Germany* 29 *May* 1994; *accepted* 16 *June* 1994)