# Enhanced Leaving Ability of Methoxy Group and Retarded Deprotonation on the Carbon Atom Linked to the 1-Position of 8-Phosphino- or 8-Amino-naphthalene

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In an attempt to lithiate a benzylic carbon, a benzyl methyl ether bearing an 8-phosphino-1-naphthyl group at the benzylic carbon is treated with *t*-butyllithium to result in the formation of a quite unexpected compound, arising not from deprotonation but from the removal of the methoxy group accompanied by the introduction of two *t*-butyl groups into the naphthalene ring.

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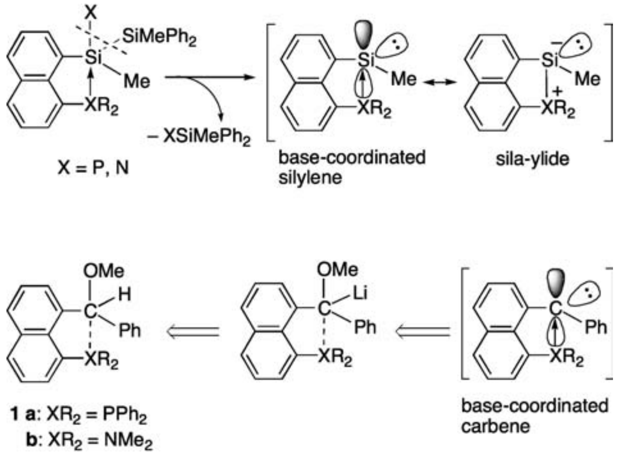
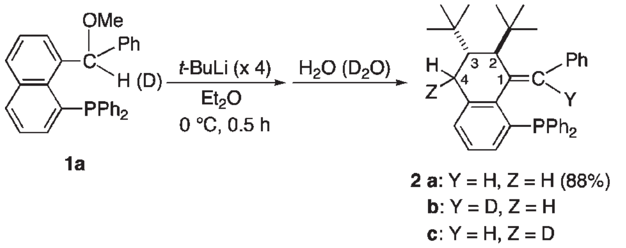
We recently reported that intramolecularly base-coordinated silylenes bearing an 8-phosphino- or 8-amino-1-naphthyl group behave as nucleophilic sila-ylides in the presence of a trapping reagent such as diphenylacetylene (Scheme 1).[1] We are interested in the behavior of the lighter congener of silicon, intramolecularly base-coordinated carbene bearing a similar structure. We intended to generate the carbene from the corresponding lithium methoxycarbenoid derived from the benzyl methyl ether **1** bearing the 8-phosphino- or 8-amino-1-naphthyl group at the benzylic carbon (Scheme 1). With the reaction of **1** with *t*-butyllithium, however, the expected deprotonation on the benzylic carbon was not observed, and instead, completely unexpected reactions have proceeded to result in the removal of a methoxy group accompanied by the introduction of two *t*-butyl groups into the naphthalene ring or to result in the deprotonation on the naphthalene and/or benzene ring carbon(s). The preliminary results of these reactions are reported in this communication.



Scheme 1.



Scheme 2.

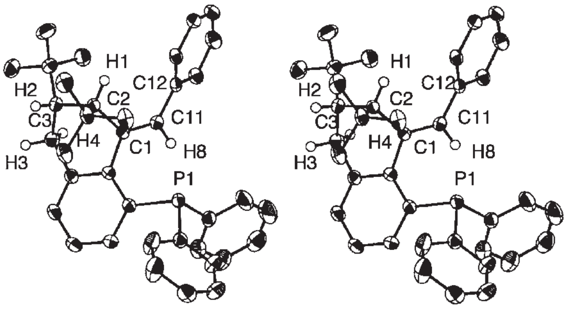
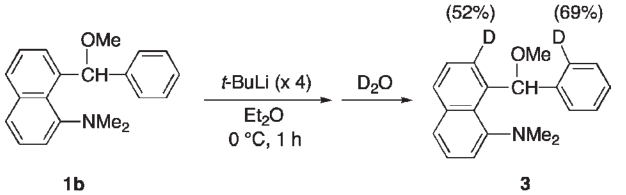


**Figure 1.** X-ray structure of **2a** in stereoview at 50% probability level. All hydrogen atoms except for H1–H4 and H8 are omitted for clarity. Selected distances [Å] and angles [deg]. C1–C11 1.345(2), C1–C2 1.526(2), C2–C3 1.567(2), C11···P1 3.203(2), C2–C1–C11–C12 1.7(3), H1–C2–C3–H2–108.

The reaction of the benzyl methyl ether **1a** bearing an 8-diphenylphosphino-1-naphthyl group with *t*-butyllithium (4 molar amount) was carried out in ether as the solvent to afford **2a** in a yield of 88% (Scheme 2) through the introduction of two *t*-butyl groups at the 2- and 3-positions of the naphthalene ring accompanied by the removal of the methoxy group and the formation of an exocyclic double bond.[2] The structure of this unexpected product was confirmed by X-ray crystallographic analysis (Figure 1).[3] The six-membered ring, dearomatized during the reaction, was found to adopt a skew-boat form with the two *t*-butyl groups in trans positions. It should be noted that only one geometrical isomer with respect to the exocyclic double bond was formed by this reaction. The benzylic D-labeled compound **1a**(D) gave the D-incorporated product **2b** as a sole product to show that the benzylic hydrogen in **1a** remained intact during the present reaction. By quenching the reaction using **1a**(H) with $D_2O$, deuterium was introduced into the aliphatic carbon C4 of the tetralin moiety to afford **2c**.

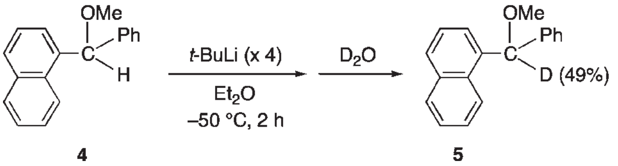
In the case of the 8-dimethylamino-1-naphthyl analogue **1b**, neither deprotonation on the benzylic carbon nor the substitution of the methoxy group by a *t*-butyl group was observed. The reaction observed was the deprotonation on the 2-carbon of the phenyl group and/or on the 2-carbon of the naphthyl group to afford **3** after quenching with $D_2O$ (Scheme 3).[4] This reaction is regarded as an MeO-directed ortho lithiation.

In a control experiment using the 8-unsubstituted analogue **4**



Scheme 3.

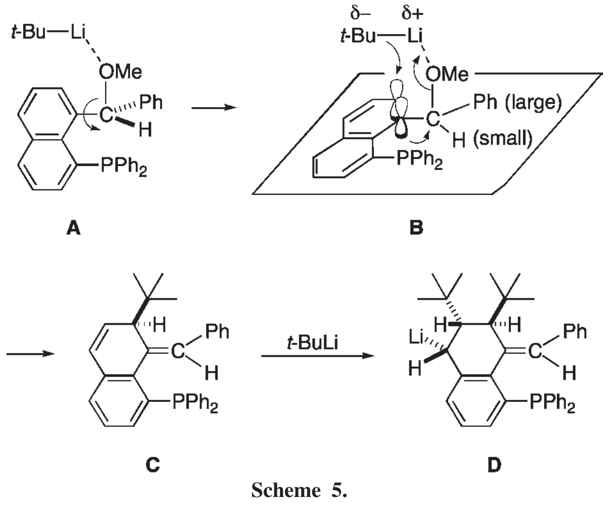
(Scheme 4), it has been clarified that, in the absence of the phosphino or amino group at the 8-position of the naphthyl group, the benzylic hydrogen atom is sufficiently acidic to be deprotonated as usual under much milder conditions to afford the benzylic D-incorporated product **5** after the quenching with $D_2O$.[5] The substitution of the methoxy group by a *t*-butyl group was not observed.



**Scheme 4.**

The results described above clearly indicate that the phosphino or amino group at the 8-position of the naphthyl group in **1a** and **1b** enhances the leaving ability of the methoxy group and retards the deprotonation on the carbon atom linked to the 1-position of the naphthyl group.

Plausible reaction courses of these unexpected reactions are visualized in Scheme 5. The first step is a Li···O interaction between *t*-butyllithium and the methoxy group to form the intermediate **A**. For the $S_N2'$ type $\gamma$ substitution to proceed in the phosphorus case **1a**, a periplanar arrangement of the C–O bond and $\pi$ orbitals of the naphthyl carbons must be attained. Because the C–O bond in **A** is presumed to be in the plane defined by the naphthalene ring due to the interaction of the phosphorus atom with the benzylic carbon anti to the methoxy group, rotation around the connecting C–C bond is required. It is probable that the direction of this rotation is controlled to avoid steric repulsion between the phenyl group on the benzylic carbon and the diphenylphosphino group, as shown by the arrow in **A**. Thus, the methoxy group and the interacting *t*-butyllithium move upward from the plane of the naphthalene ring to afford the intermediate **B** (or a transition structure), in which the $\gamma$ substitution favorably proceeds to form the intermediate **C**.[6] The final step may be the 1,2-addition of the second *t*-butyllithium to the dearomatized endocyclic double bond from the other side of the already introduced *t*-butyl group to afford **D** followed by the protiodelithiation during quenching with water. The MeO-directed ortho lithiation in the nitrogen case **1b** seems to proceed at the stage of the Li···O interaction described above, namely in the intermediate analogous to **A** in Scheme 5 before the rotation of the C–C bond.



**Scheme 5.**

The origin of the effect of the phosphorus or nitrogen atom described above is presumed to be the through-space interaction of its lone pair electrons with the carbon atom linked to the 1-position.[7–9] The P···C distance is expected to be longer than the N···C distance based on the comparison of X-ray structures of closely related compounds.[10,11] The longer P···C distance may be responsible for the facile rotation of the C–C bond in phosphine-substituted **1a** shown in Scheme 5. To clarify the details, investigation is continued in our laboratory.

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Dedicated to Prof. Teruaki Mukaiyama on the occasion of his 75th Birthday.

### References and Notes

1 a) K. Tamao, M. Asahara, T. Saeki, S.-G. Feng, A. Kawachi, and A. Toshimitsu, *Chem. Lett.*, **2000**, 600. b) A. Toshimitsu, T. Saeki, and K. Tamao, *J. Am. Chem. Soc.*, **123**, 9210 (2001). c) Review: K. Tamao, M. Asahara, T. Saeki, and A. Toshimitsu, *J. Organomet. Chem.*, **600**, 118 (2000).

2 $^1$H NMR spectrum of **2a** (in $C_6D_6$) $\delta$ 0.80 (s, 9H), 1.08 (s, 9H), 1.89 (br.t, 1H, $J = \sim 9$ Hz), 2.50 (br.dd, 1H, $J = \sim 15, \sim 9$ Hz), 2.67 (br.dd, 1H, $J = \sim 15, \sim 9$ Hz), 3.61 (br.s, 1H), 6.53 (d, 1H, $J = 3.9$ Hz), 6.9–7.2 (m, 11H), 7.3–7.5 (m, 3H), 7.5–7.6 (m, 4H).

3 Crystallographic data for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication nos. CCDC-173587 (**2a**), 175050 (**6a**), and 175049 (**6b**). Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB1 1EZ, U.K. (fax: (+44)1223-336-033; e-mail: deposit@ccdc.cam.ac.uk.

4 $^1$H NMR spectrum of **1b** (in $C_6D_6$) (signals were assigned by the H–H COSY measurement) $\delta$ 2.29 (s, 3H), 2.44 (s, 3H), 3.45 (s, 3H), 7.02 (tt, 1H, $J = 7.4$, 1.2 Hz, Ph-4), 7.06–7.15 (m, 3H, Ph-3,5 Np-7), 7.21 (t, 1H, $J = 8.1$ Hz, Np-6), 7.36–7.43 (m, 3H, Ph-2,6 Np-3), 7.52 (dd, 1H, $J = 8.4$, 1.2 Hz, Np-5), 7.65 (dd, 1H, $J = 8.0$, 1.2 Hz, Np-4), 8.28 (dd, 1H, $J = 7.4$, 1.2 Hz, Np-2). As the signals due to benzylic and Np-6 hydrogens overlapped with that of solvent, their intensities were confirmed by the measurement in acetone-$d_6$ [$\delta$ 7.11 (s, 1H), 7.38 (t, 1H, $J = 7.6$ Hz)].

5 $^1$H NMR spectrum of **4** (in $C_6D_6$) (signals were assigned by the H–H COSY measurement) $\delta$ 3.23 (s, 3H), 5.77 (s, 1H, C*H*OMe), 7.02–7.17 (m, 3H, Ph-3,4,5), 7.22–7.27 (m, 2H, Np-6,7), 7.32 (t, 1H, $J = 7.8$ Hz, Np-3), 7.46 (br.d, 2H, $J = \sim 7.2$ Hz, Ph-2,6), 7.61–7.69 (m, 3H, Np-2,4,5), 8.23 (dd, 1H, $J = 7.4$, 1.2 Hz, Np-8).

6 One of the enantioisomers is shown in Scheme 3. The mirror image of **A** affords the mirror image of **D**.

7 The through-space C$\underline{\mathrm{H}}$···$\underline{\mathrm{P}}$ spin-spin coupling was observed in the $^1$H NMR spectrum of **1a** (in $C_6D_6$) [$\delta$ 7.75 (d, 1H, $J = 15.9$ Hz)].

8 The interaction between the cationic carbon atom located at the 9-position of anthracene and two oxygen atoms of methoxy groups at 1- and 8-positions of the anthracene has been reported; K.-y. Akiba, M. Yamashita, Y. Yamamoto, and S. Nagase, *J. Am. Chem. Soc.*, **121**, 10644 (1999).

9 It is not yet clear whether the reluctant deprotonation is due to the reduced acidity of the hydrogen atom or due to the steric hindrance by the phosphino or amino group.

10 The X-ray crystallographic analyses of the alcohols bearing a structure similar to those of **1a** and **1b**, namely, 1-(8-diphenylphosphino-1-naphthyl)-1-phenylmethanol **6a** and 1-(8-dimethylamino-1-naphthyl)-1-phenylmethanol **6b**, showed that C···P and C···N distances were 3.061(3) Å and 2.861(2) Å, respectively. The former corresponds to 87% and the latter to 88% of the sum of the van der Waals radii (C···P, 3.50 Å; C···N, 3.25 Å).[11]

11 A. Bondi, *J. Phys. Chem.*, **68**, 441 (1964).