Tetrahedron Letters, Vol.31, No.20, pp 2925-2928, 1990
Printed in Great Britain

0040-4039/90 $3.00 + .00
Pergamon Press plc

ORTHO LITHIATION DIRECTED BY AMINO GROUPS ON SILICON IN PHENYLSILANE DERIVATIVES[1]

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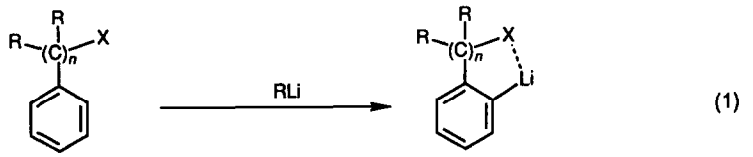
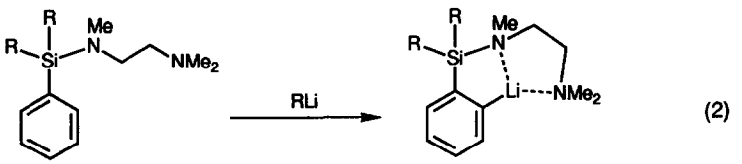
Summary: Phenylsilanes, which contain trimethylethylenediamino ($Me_2NCH_2CH_2NMe$-) group(s) on silicon, undergo selective *ortho* lithiation by treatment with *t*-BuLi, providing a new method for the synthesis of *ortho* substituted phenylsilane derivatives.

Functional group directed *ortho* metalation of aromatic compounds constitutes an elegant method for selective derivatization of aromatic compounds (eq 1).[2] There has been, however, no attempt for silyl-substituted aromatic compounds. We have now found that the *N,N,N'*-trimethylethylenediamino group ($Me_2NCH_2CH_2NMe$-; hereafter abbreviated to TMEDA-) on silicon exhibits a strong directing effect for specific *ortho* lithiation (eq 2). Reported herein are our initial results on the new method for the synthesis of *ortho* substituted phenylsilanes.



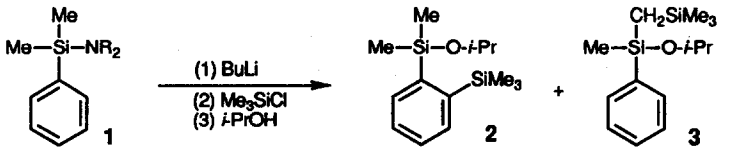
(1)



(2)

The efficiency for the *ortho* lithiation has been found to be greatly dependent on the nature of amino group and butyllithium, as determined in metalation of phenyldimethylaminosilanes **1** as model compounds (Scheme I), in which there are two possibilities for lithiation, the *ortho* lithiation (**2**) and lithiation of the methyl group (**3**). With *t*-BuLi in pentane, the TMEDA- group on silicon exhibited specifically a high selectivity for *ortho* lithiation, whereas the methyl-lithiation[3] predominated (conversion < 50%) with other amino groups such as -N(*i*-Pr)$CH_2CH_2NMe_2$, -N(*i*-Pr)$CH_2CH_2CH_2NMe_2$, 1-morpholino

Scheme I



[NR_2 = $NMeCH_2CH_2NMe_2$]

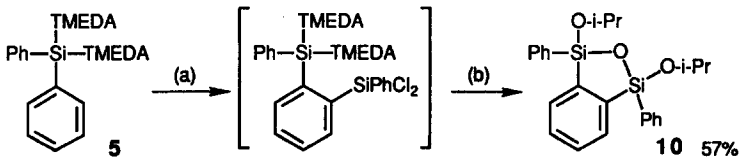
Buthyllitium	temp (°C)	time (h)	Yield (%) 2	3
t-BuLi	-78	2	52	6
s-BuLi	0	15	12	39
n-BuLi	0	40	1	32

and *N*-methylpiperazino groups and no metalation was observed with -NEt_2 group. With $PhMe_2Si$(-TMEDA), the highest selectivity for the *ortho* lithiation was attained with *t*-BuLi, while the methyl-lithiation occurred preferentially with *s*-BuLi or *n*-BuLi, as shown in Scheme I.[4] These results revealed that the TMEDA- group is the most suitable directing and activating ligand and *t*-BuLi should be the metalation reagent of choice.

Representative results obtained with phenyltriaminosilane (**4**),[5] diphenyldiaminosilane (**5**),[5] and triphenylaminosilane (**6**)[5] are summarized in Table I. In all cases the metalation was carried out at 0°C ~ room temperature for 2 h with 2.8 equiv of *t*-BuLi. Quenching with electrophiles was usually followed by treatment with *i*-PrOH alone (in the case of Me_3SiCl) or with dry *i*-PrOH/HCl (in other cases) to convert the amino groups into more stable, easy-to-handle isopropoxysilane derivatives which were isolated by distillation or column chromatography on silica gel. In all cases only one *ortho* position was lithiated, no di-lithiation on the same phenyl ring or on two different rings being observed even in the presence of a large excess amount of *t*-BuLi. In addition to the Me_3Si group, HMe_2Si, Me_3Sn, Me, CO_2Et, and iodine groups can be introduced onto the *ortho* position in moderate overall yields (entries 3 ~ 7).[6]

An unambiguous proof for the *ortho* metalation[4] has been obtained by formation of a cyclic siloxane derivative **10**[6,7] from **5** (eq 3).

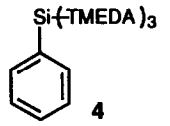
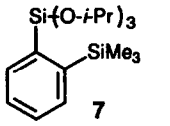
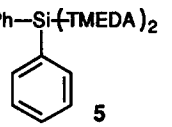
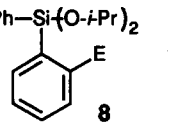
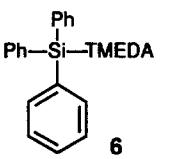
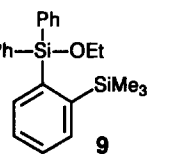
In a *para*-fluorophenyl derivative **11**, lithiation occurred selectively at the position *ortho* to the aminosilyl group to give **12** (eq 4), not to the fluorine atom which has been known to act as a directing substituent for *ortho*-metalation.[2] The parent phenyl group in **11** remained intact.



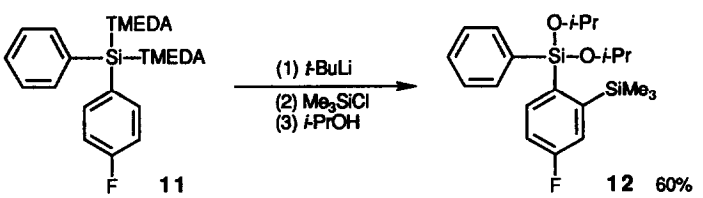
(3)

(a) (1) *t*-BuLi, 0 °C to room temperature, 2 h. (2) $PhSiCl_3$, 50 °C, 3 h.
(b) (1) *i*-PrOH, room temperature, 12 h. (2) Et_3N, H_2O (1 equiv).

Table 1. Ortho lithiation of phenylaminosilanes [a]

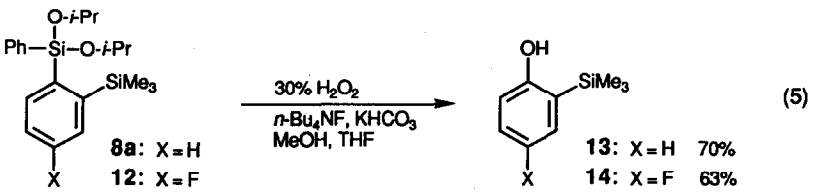
entry	aminosilane [b]	electrophile	product	yield (%)[c]
1	 **4**	Me_3SiCl	 **7**	50
	 **5**		 **8**	
2		Me_3SiCl	**a** E = $SiMe_3$	97
3		HMe_2SiCl	**b** E = $SiMe_2H$	56
4		Me_3SnCl	**c** E = $SnMe_3$	55
5		Me_2SO_4 [d]	**d** E = Me	44
6		$ClCO_2Et$ [d]	**e** E = CO_2Et	30
7		I_2 [d]	**f** E = I	60
8	 **6**	Me_3SiCl [e]	 **9**	36

[a] Unless otherwise stated, the reaction was carried out on a 1 mmol scale as follows; To a solution of an aminophenylsilane in hexane (2 ml) was added a pentane solution of *t*-BuLi (2.8 equiv) at 0 °C and the mixture was stirred at room temperature for 2 h. Addition of an electrophile (10 equiv) to the mixture was followed by heating at 50 °C for 3 h. The mixture was worked up by treatment with *i*-PrOH (5 equiv) at room temperature overnight, followed by addition of a 10% aqueous solution of NH_4Cl. The mixture was extracted with hexane, washed with a saturated NaCl solution, and dried over K_2CO_3. Column chromatography on silica gel afforded the pure product. [b] The -$NMeCH_2CH_2NMe_2$ group on silicon is abbreviated to -TMEDA. [c] Isolated overall yield. [d] The electrophile (5 equiv) was added at -78 °C. After stirring at 0 °C to room temperature for 2 h, the mixture was quenched with 2 N dry HCl in *i*-PrOH, followed by the usual workup. [e] Work-up with dry EtOH.



(4)

The *ortho* substituted alkoxylsilanes **8a** and **12** were transformed into the corresponding *ortho*-trimethylsilylphenol derivatives **13** and **14**, respectively, by hydrogen peroxide oxidation[8] providing the additional proof for the *ortho* metalation (eq 5). The present overall transformation may be useful as a new method for the synthesis of *ortho* substituted phenol derivatives. It should be mentioned that the *ortho* metalation of phenol itself has only recently been developed.[9]



(5)

While much remained to be refined, the present procedure has afforded a new useful methodology for the synthesis of hitherto hardly accessible *ortho* substituted arylsilanes containing functional groups on silicon. It may especially be noted that unsymmetrical *ortho*-disilylbenzenes can readily been synthesized by the present method, while symmetrical *ortho*-disilylbenzenes have so far been used as a reactive monomer[10] and useful synthetic reagents,[11] and shown to exhibit unusual reactivities.[12,13]

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4. The *ortho*-disilylbenzene **2** has been reported previously: Ishikawa, M.; Fuchikami, T.; Kumada, M. *J. Organomet. Chem.* **1977**, *133*, 19.
5. The aminosilanes were prepared by treatment of the corresponding chlorosilanes with Li-$NMeCH_2$-CH_2NMe_2 in THF, followed by filtration and distillation in vacuo.
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13. We thank Shin-etsu Chemical Co., Ltd. for a gift of some silicon precursors.

(Received in Japan 28 February 1990)