

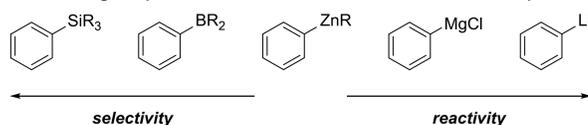


Copper-Catalyzed Silylations of Aldehydes

Courtney E. Nuyen, Jake R. Wilkinson, Travis H. Reiner, and Ryan Van Hoveln*
Department of Chemistry and Physics, Indiana State University, Terre Haute, IN 47809

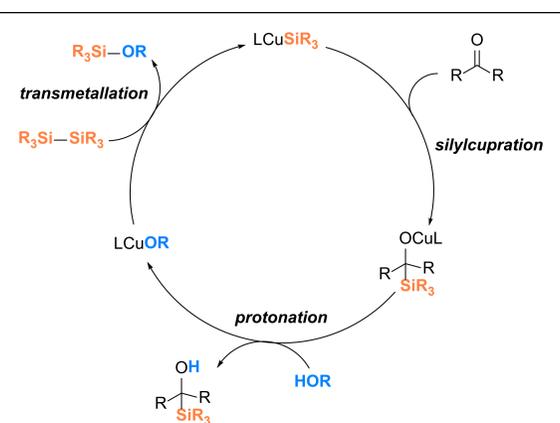
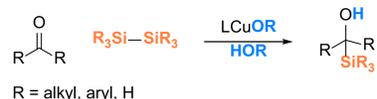
Introduction

In organic synthesis, carbon nucleophiles serve as useful tools that can be added to various functional groups in order to build molecular complexity.¹ Typical carbon nucleophiles include organosilanes, -borons, -zincs, magnesiums, and -lithiums. Organosilanes are unique because of their high selectivity and mild reactivity. These features allow for different modes of reactivity and functional group tolerance than other carbon nucleophiles.

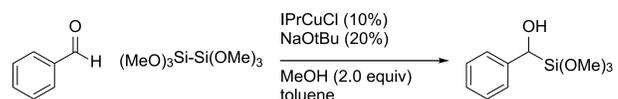


Currently, the most efficient methods for developing organosilanes utilize expensive heavy-metal catalysts like platinum and palladium or silylboranes that are expensive and air and water sensitive. Our approach, alternatively, uses a copper metal catalyst and disilane silicon source. This research aims to develop catalytic silylations of aldehydes to form the corresponding α -silyl alcohols.²⁻³

Proposed Mechanism for Hydrosilylation of Carbonyls



Previous Work



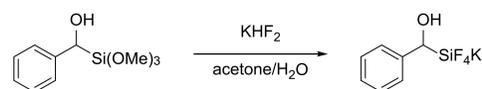
The hydrosilylation of benzaldehyde was optimized and believed to produce an α -silyl alcohol in high yield. The product was analyzed using NMR with an internal standard. Although this reaction appeared to be successful, concentration resulted in decomposition of the product. Efforts at protecting the alcohol were unsuccessful.

Objectives

1. Isolate and characterize the α -silyl alcohol product.
2. Establish a substrate scope of various α -silyl alcohols.

Converting the Alcohol to an Organotetrafluorosilicate

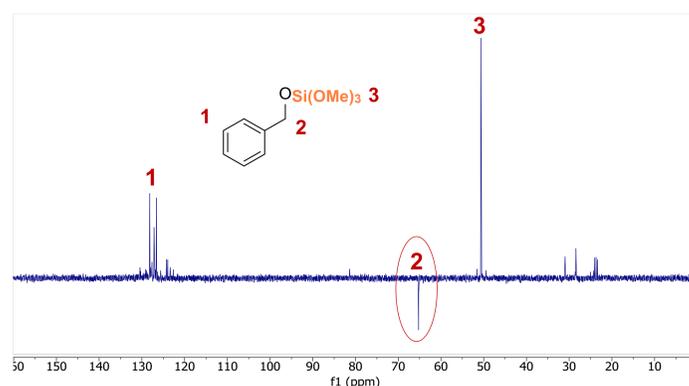
Trialkoxysilanes can react with KHF_2 to selectively form the corresponding organotetrafluorosilicates in high yields with good functional group tolerance.



Therefore, we propose that converting the α -silyl alcohol to an organotetrafluorosilicate is a reasonable transformation that may solve the isolation problem. This conversion will add an additional bond to the silicon group and therefore decrease the likelihood of a reaction between the alcohol group and trimethoxysilyl group. Unfortunately, this reaction did not produce the desired organotetrafluorosilicate.

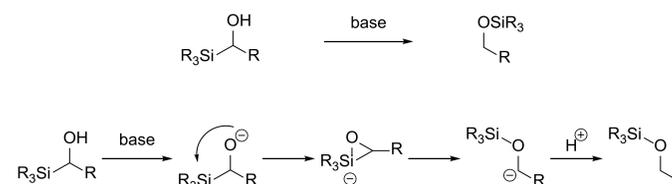
This effort at isolating the product was not promising, so we aimed to fully characterize the product in solution.

Characterization in Solution

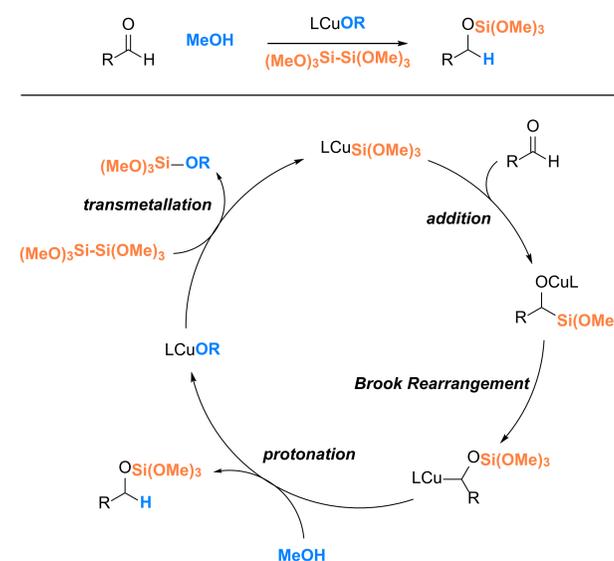


A series of NMR spectra were obtained including ^1H -NMR, ^{13}C -NMR, DEPT-135, HSQC, and HMBC. The DEPT-135 spectrum revealed the presence of a CH_2 carbon. This result does not correspond with the understood product, the α -silyl alcohol, but does correspond with another possible reaction, the Brook Rearrangement.

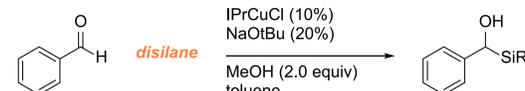
Brook Rearrangement



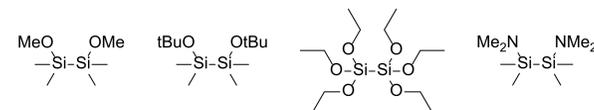
The Brook Rearrangement of an α -silyl alcohol is an intramolecular migration of a silyl group from carbon to oxygen in the presence of a catalytic amount of base.⁴ This transformation is competing with protonation of the copper alkoxide. In order to form the α -silyl alcohol, conditions that favor protonation over Brook Rearrangement need to be found.



Other Disilanes



entry	disilane	SM	Brook	yield
1	$\text{Me}_2\text{MeOSi-SiOMeMe}_2$	0%	98%	0%
2	$\text{Me}_2\text{tBuOSi-SiOtBuMe}_2$	61%	0%	9%
3	$(\text{EtO})_3\text{Si-Si(OEt)}_3$	0%	59%	0%
4	$\text{Me}_2(\text{Me}_2\text{N})\text{Si-Si(NMe}_2\text{)Me}_2$	0%	0%	79%



We propose that using a less electrophilic silane may make it less susceptible to attack from the nucleophilic oxygen. While entry 4 appears to have made the desired product, it has not yet been confirmed.

Future Directions

1. Determine the best method for producing the α -silyl alcohol by altering the disilane and ligand.
2. Isolate the α -silyl alcohol and establish a substrate scope.
3. Explore other types of copper-catalyzed reactivity of α -silyl alcohols and determine if they can be used in umpolung reactions.

Conclusions

We have shown that the silylation of benzaldehyde, previously believed to produce an α -silyl alcohol, favors formation of a silyl ether through Brook Rearrangement. This discovery explains why protecting the alcohol and converting the alcohol to an organotetrafluorosilicate were not successful. Additionally, altering the disilane can vary the product distribution.

Acknowledgements

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