temperature two regioisomeric products could be isolated in a 1.6:1 ratio. Upon O-methylation and spectral comparison with **10**, the major isomer was found to be of incorrect regiochemistry. After a number of additional experiments we have found that reaction of **14** with 5 molar equiv of the amine in the presence of potassium carbonate, 18-crown-6, and a catalytic amount of DMAP followed by O-methylation provides solely the desired regioisomer in 45% yield. The new quinone **4** was treated in the same way as described for **10** in Scheme II to furnish the desired cyclization precursor **5**. This phosphonate could be cyclized to **6** in at best 28% yield on employing the Wadsworth–Emmons reaction conditions described by Masamune and Roush.[14] Formation of small amounts of dimer is observed along with the β-elimination product **16**. Since in the synthesis of rubradirin itself, the center α to the carbonyl group will contain no hydrogen atoms, such a β-elimination process will be precluded, and therefore higher yields of the bridged product may be expected. The lower yield observed in the cyclization reaction of **5** compared to that found for the cyclization of **12** is expected in light of the more severe transannular interactions and bond angle distortions which must develop in the transition state for ring closure.[15]

Acknowledgment. We are indebted to the National Institutes of Health (1RO1AI/GM17324) for their support of these studies. We thank J. Abola and J. Mandel for the X-ray structure determination carried out on the NIH-sponsored (1-S10-RR02381-01) X-ray diffractometer of the University of Pittsburgh Chemistry Department. Y.X. thanks Nankai University, Tianjin, China, for a one-year graduate scholarship.

Supplementary Material Available: Spectral data for compounds **1**, **3**, **4**, **6**, and **8–16** and X-ray analysis of **13** (19 pages). Ordering information is given on any current masthead page.

(14) Blanchette, M. A.; Choy, W.; Davis, J. T.; Essenfeld, A. P.; Masamune, S.; Roush, W. R.; Sakai, T. *Tetrahedron Lett.* **1984**, *25*, 2183.
(15) Deslongchamps, P.; Lamothe, S.; Lin, H.-S. *Can. J. Chem.* **1984**, *62*, 2395.

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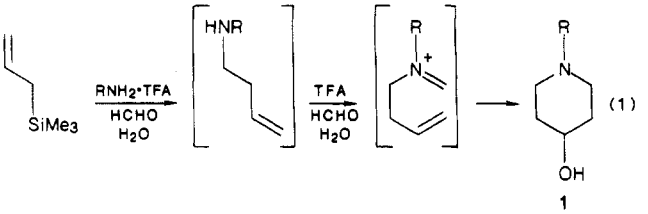
Reactions of Allylstannanes with in Situ Generated Immonium Salts in Protic Solvent: A Facile Aminomethano Destannylation Process

Summary: In situ generated immonium salts derived from primary amines and formaldehyde upon exposure to allylstannanes in protic media undergo rapid, facile aminomethano destannylation, giving rise to bishomoallylamines with no evidence of piperidine formation.

Sir: In a previous study[1] we observed that in situ generated immonium salts derived from primary amines upon exposure to allyltrimethylsilane in water undergo an aminomethano desilylation–cyclization process leading to N-substituted piperidines (cf. eq 1). Use of secondary



(1)

1

amines leads only to products of aminomethano desilylation (cf. eq 2). For example addition of 1.1 equiv of

$$C_6H_5CH_2NHMe\cdot TFA \xrightarrow[Me_3SiCH_2CH=CH_2]{HCHO,\ H_2O} \underset{50\ °C,\ 68\ h}{} C_6H_5CH_2N(Me)CH_2CH_2CH=CH_2 \quad (2)$$

2

allyltrimethylsilane to a 3.0 M solution of *N*-benzyl-*N*-methylammonium trifluoroacetate in water containing 2.3 equiv of 37% aqueous formaldehyde gives rise after 68 h at 50 °C to a 76% yield of tertiary amine **2** (eq 2). In our preliminary survey[1] on the reaction of a number of allylsilanes with immonium ions, we found, in general, that whereas yields ranged from good to excellent, *reaction times were extremely long.* In order to improve upon this process we set out to examine the reaction of allylstannanes with immonium ions. We detail below the results of this investigation.

The high reactivity and regiospecificity associated with the chemistry of allylstannanes,[2] which has been attributed to extensive interaction between the σ_{C-Sn} and π orbitals,[3] and the fact that the allylstannane double bond is more nucleophilic than an allylsilane double bond,[3] led us to investigate the reaction of in situ generated immonium ions with allylstannanes. In a preliminary experiment, a 0.27 M solution of *N*-benzylammonium trifluoroacetate in a 1:1 mixture of methanol and chloroform at ambient temperature was treated with 2.1 equiv of 37% aqueous formaldehyde and 2.0 equiv of allyltri-*n*-butylstannane. After 4 h the homogeneous reaction mixture was quenched with 5% hydrochloric acid solution and was washed with hexane–ether (4:1). Neutralization of the aqueous phase with base provided a 97% yield of *N*-benzyl-*N*,*N*-bishomoallylamine (**3**) (cf equation 3). No trace of piperidine **1** (R = benzyl) could be detected.

$$C_6H_5CH_2NH_2\cdot TFA \xrightarrow[Bu_3SnCH_2CH=CH_2]{HCHO} \underset{4\ h}{\underset{MeOH-CHCl_3}{}} C_6H_5CH_2N(CH_2CH_2CH=CH_2)_2 \quad (3)$$

3

Also examined, under identical conditions, was the reaction of *N*-methyl-*N*-benzylammonium trifluoroacetate with formaldehyde and allyltributylstannane which provided after 2 h a quantitative yield of tertiary amine **2** (eq 4).[4] It is of interest to note that whereas the reaction of

$$C_6H_5CH_2NHMe\cdot TFA \xrightarrow[Bu_3SnCH_2CH=CH_2]{HCHO} \underset{2\ h}{\underset{MeOH-CHCl_3}{}} C_6H_5CH_2N(Me)CH_2CH_2CH=CH_2 \quad (4)$$

2

(1) Larsen, S. D.; Grieco, P. A.; Fobare, W. F. *J. Am. Chem. Soc.* **1986**, *108*, 3512.

(2) For the reaction of allylstannanes with aldehydes and ketones catalyzed by Lewis acids, see: Pereyre, M.; Quintard, J.-P. *Pure Appl. Chem.* **1981**, *53*, 2401.
(3) Weidner, U.; Schweig, A. *J. Organomet. Chem.* **1972**, *39*, 261. Brown, R. S.; Eaton, D. F.; Hosomi, A.; Traylor, T. G.; Wright, J. M. *Ibid.* **1974**, *66*, 249. Hartman, G. D.; Traylor, T. G. *Tetrahedron Lett.* **1975**, 939.

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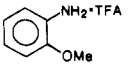
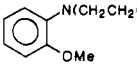
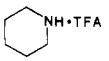
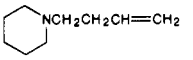
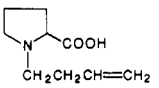
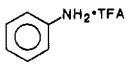
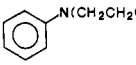
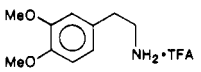
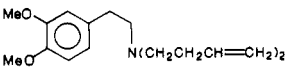
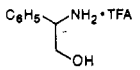
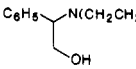
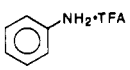
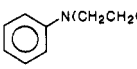
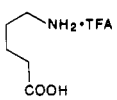
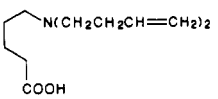
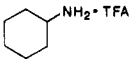
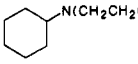
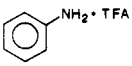
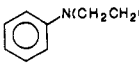
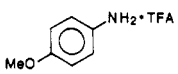
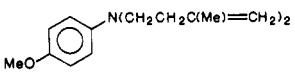
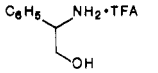
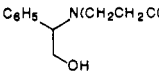
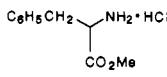
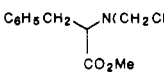
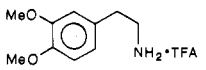
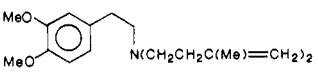
Table I. Reaction of Allyltributylstannone with N-Substituted Methyleneimmonium Salts[a]

entry	amine	time, h	product	yield, %[b]
1	$MeO_2CCH_2NH_2$·HCl	3	$MeO_2CCH_2N(CH_2CH_2CH{=}CH_2)_2$	99
2[c]	Et_2NH·TFA	2	$Et_2NCH_2CH_2CH{=}CH_2$	100
3		2		88
4	$MeNH_2$·TFA	2	$MeN(CH_2CH_2CH{=}CH_2)_2$	100
5	n-$C_6H_{13}NH_2$·TFA	3	n-$C_6H_{13}N(CH_2CH_2CH{=}CH_2)_2$	100
6		3		98
7	proline	2		100
8		2		75
9[d,e]		4		82
10		24		89
11		6		84
12[f]		4		99

[a] In the case of primary amines, all reactions were run 0.26–0.85 M in methanol–chloroform (1:1), unless stated otherwise, using 2.1 equiv of allyltributylstannone and 2.2 equiv of 37% aqueous formaldehyde solution. For secondary amines, 1.05 equiv of allylstannane and 1.1 equiv of aqueous formaldehyde were employed. [b] Isolated yields. [c] Ethanol–chloroform (1:1). [d] Ethanol–chloroform (2:1). [e] Approximately 10% of the homoallylated tetrahydroisoquinoline was also isolated. [f] Ethanol–chloroform (5:1).

Table II. Reaction of Methallyltributylstannane with N-Substituted Methyleneimmonium Salts[a]

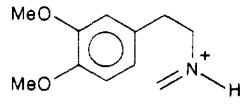
entry	amine	time, h	product	yield, %[b]
1	$C_6H_5CH_2NH_2$·TFA	0.5	$C_6H_5CH_2N(CH_2CH_2C(Me){=}CH_2)_2$	93
2	Et_2NH·HCl	4	$Et_2NCH_2CH_2C(Me){=}CH_2$	100
3		4		100
4		4		80
5		4		90
6	$EtO_2CCH_2NH_2$·HCl	4	$EtO_2CCH_2N(CH_2CH_2C(Me){=}CH_2)_2$	100
7	$C_6H_5CH_2NHMe$·TFA	2	$C_6H_5CH_2N(Me)CH_2CH_2C(Me){=}CH_2$	100
8		4		98
9		4		78
10		4		94

[a] All reactions were run 0.14–0.76 M in methanol–chloroform (1:1) unless stated otherwise. In the case of primary amines 2.1 equiv of methallyltributylstannane and 2.2 equiv of 37% aqueous formaldehyde solution were employed. For secondary amines, 1.05 equiv of methallylstannane and 1.1 equiv of aqueous formaldehyde were employed. [b] Isolated yields.

N-methyl-*N*-benzylammonium trifluoroacetate with formaldehyde and allyltributylstannane was essentially complete after 2 h at ambient temperature, use of allyltrimethylsilane required 68 h at 50 °C to realize a 76% yield of **2**. These observations are in keeping with theory which suggests that the double bond of an allylstannane is more nucleophilic than that of an allylsilane. Given the more nucleophilic nature of the double bond in allyltributylstannane it is indeed surprising that no protodestannylation[5] was observed.

(4) The reactions depicted in eq 3 and 4 can be carried out exclusively in water. However, use of water as solvent gives rise to heterogeneous reaction mixtures which require vigorous stirring. Use of methanol–chloroform (1:1) gives rise, in most cases, to homogeneous reaction mixtures. The reaction depicted in eq 4 requires 4 h in water in order to realize a near quantitative yield of **2**.

The generality of the aminomethano destannylation process was established by examining a number of primary and secondary amines. Table I reveals that aminomethano destannylation proceeds efficiently in excellent yields even in the presence of hydroxyl groups and carboxylic acids. Particularly noteworthy is the reaction (entry 9) of the immonium ion **4**, derived from homoveratrylamine, with allyltributylstannane which provides an 82% yield of tertiary amine **5** along with only 10% of the Pictet–Spengler cyclization product **6**. Once again the intermolecular process is faster than the intramolecular ring closure (cf. eq 3).



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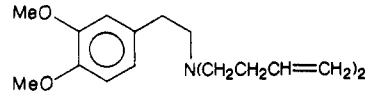

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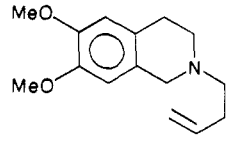
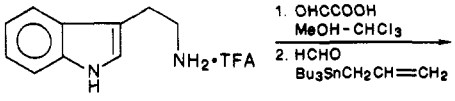
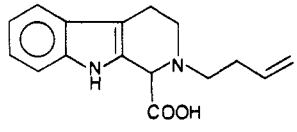


6

In order to further explore the potential of the aminomethano destannylation reaction for alkaloid synthesis, we exposed the trifluoroacetate salt **7** of tryptamine (0.18 M in $MeOH{\cdot}CHCl_3$, 1:1) to 1.0 equiv of a 50% aqueous solution of glyoxylic acid over a 24-h period followed by the sequential addition of 2.05 equiv of 37% aqueous formaldehyde solution and 1.0 equiv of allyltributylstannane. After an additional 5 h at ambient temperature, workup provided a 73% yield of crystalline acid **8**, mp 167–168 °C.



7

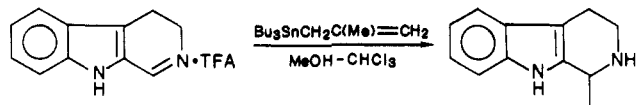


8

(5) Mangravite, J. A.; Verdone, J. A.; Kuivila, H. G. *J. Organomet. Chem.* **1976**, *104*, 303.

In a separate series of experiments, we examined the reaction of a number of amines with methallyltributylstannane.[6] Once again the aminomethano destannylation process appears to be general as summarized in Table II. In the case of homoveratrylamine (entry 10), a 94% yield of bishomoallylamine was obtained with no trace of the corresponding tetrahydroisoquinoline being detected.

The aminomethano destannylation process can also be carried out on preformed immonium salts. For example treatment of a 0.76 M solution of the trifluoroacetate salt of dihydro-β-carboline **9** in methanol–chloroform (1:1) with 1.0 equiv of methallyltributylstannane for 1 h at ambient temperature provided a 95% yield of the tetrahydro-β-carboline **10**.[7]



9

10

Further studies exploring the reactions of immonium salts with allylstannanes are in progress.

Acknowledgment. This investigation was supported in part by a grant from the National Science Foundation. The 300-MHz NMR instrument (Varian XL-300) used in the above studies was purchased with funds provided by the National Institutes of Health (Grant RR-1882). We are grateful to David Parker for preparing methallyltributylstannane.

(6) Abel, E. W.; Rawley, R. J. *J. Organomet. Chem.* **1975**, *84*, 199.

(7) A recent report in the literature [Borg, R. M.; Mariano, P. A. *Tetrahedron Lett.* **1986**, *27*, 2821] describes the photoaddition of allylstannanes to 1-methyl-2-phenyl-1-pyrrolinium perchlorate (i). It is pointed out by the authors that *additions did not occur in the absence of light* under conditions [ca. 10^{-3} M concentration in immonium salt, 25 °C, 1–4 h] employed for the photoaddition reactions.

(8) Recipient of a Predoctoral Fellowship from La Universidad de Los Andes, Merida, Venezuela.

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Additions and Corrections

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Kwan Soo Kim,* Yang Heon Song, Bong Ho Lee, and Chi Sun Hahn. Efficient and Selective Cleavage of Acetals and Ketals Using Ferric Chloride Adsorbed on Silica Gel.

Page 405, column 2, line 17 of Experimental Section. "60 °C" should read "room temperature".

Page 407, column 1, top. Dr. C. A. Zezza has called to our attention that the "0.1 g of $FeCl_3$-SiO_2 reagent" (prepared from $FeCl_3{\cdot}6H_2O$; see page 405, column 2) would contain only 0.24 mmol of water, an amount inadequate to hydrolyze 5 mmol of acetal (or ketal). Additional water is needed; in our case, it may have come from the solvent or from the silica gel. Other users may find it necessary to add additional water in the Cleavage Procedure (p 407, column 1, top).