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CONTROL OF REGIOCHEMISTRY IN BISMETALLATION OF 1-DECYNE

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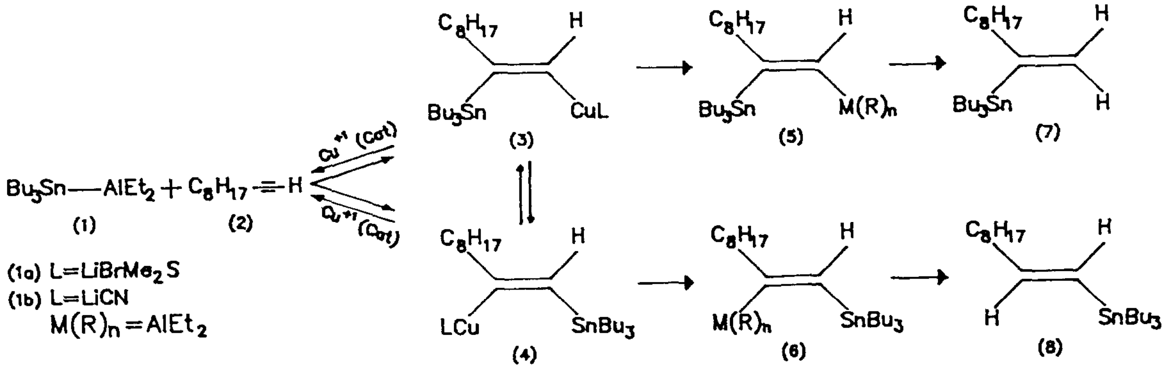
Summary: Copper(I) catalyzed stannylalumination of 1-decyne proceeds via reversible stannylcupration. The kinetically favored regioisomer is the 1-stannylalkene whereas the thermodynamically favored regioisomer is the 2-stannyl derivative. Solvent (THF vs THF:HMPA) and copper(I) counter ion control the regiochemistry.

Reaction of tin and silicon metalloid reagents (Sn-M, M=Li[1], Na[1], Al[2], Zn[2], Mg[2], Mn[3], Cu[4], Si[5a], Sn[5b], B[6a]; Si-M, M=Mn[3], B[6a], Al[6b], Mg[6b,c], Zn[6b,7], Si[8]) with 1-alkynes yield cis-1,2-dimetallo-1-alkenes in which the vinyl carbon-metal bonds have different reactivity. Elaboration of these organometallics involves selective reaction of the more reactive vinyl organometallic center (usually C-M) with an electrophile. Reaction of the second vinyl organometallic center (usually C-Si or C-Sn) with an electrophile commonly involves activation by way of Lewis acid catalysis (Si) or transmetallation (Sn). The extensive transmetallation chemistry of stannanes makes bismetallation of alkynes by tin based metalloids of particular synthetic interest.



Several problems beset tin based bismetallation of alkynes. Reactions utilizing tin based reagents wherein M=Al^2, Mg^2, Zn^2, Mn^3 and Cu^4 often require a two or three fold excess of reagent to achieve high alkyne consumption. Most excess tin reagent is converted to hexaalkylditins which can complicate product isolation. Addition of Sn-Cu reagents to alkynes requires consumption of one vinyl center by *in situ* protonolysis to overcome an unfavorable adduct ⇌ alkyne equilibrium. Regiospecificity is high for some stannylation reactions (3/4: Sn-Cu^4,100/0; Sn-Zn^2,95/5; Sn-Si^{5a},90/10) but low for others (Sn-Al^2, 62/38; Sn-Mg^2,30/70).

In an effort to find conditions under which reaction of $Bu_3SnAlEt_2$ with 2 would yield low amounts of tin byproducts we examined several alternative methods of performing the reaction. We found that reaction of tributylstannyllithium derived from the reaction of LDA and tributyltin hydride[9] with diethylaluminium chloride gave the cleanest preparation of $Bu_3SnAlEt_2$. Addition of 1-decyne (2) to 3 equivalents of $Bu_3SnAlEt_2$ in THF in the presence of a catalytic amount of CuCN gave, after protonolysis, 7 and 8 in a 91:9 ratio (Table 1, entry 1) and many tin containing side products. Slow addition of one equivalent of 1-decyne to $Bu_3SnAlEt_2$ at -30°C resulted in high alkyne consumption and minimal formation of hexabutylditin (Table 1, entry 2). Inverse addition of $Bu_3SnAlEt_2$ to 2 consistently gave, after protonolysis, lower yields of 7 and 8 (Table 1, compare entry 2 with 3). When the reaction of $Bu_3SnAlEt_2$ with 2 was conducted in THF:HMPA the regioselectivity of the reaction reversed to give a 6 to 94 mixture of 7 to 8 upon workup (Table 1, entry 4).

Table 1. Addition of Bu_3SnM_x to 1-decyne[a].

Entry	Bu_3SnM_x	$\frac{Bu_3SnM_x}{Alkyne}$	Catalyst (solvent)	Temp	7[b]	8[b]	%yield[b] 7 + 8 (alkyne unreacted)	Tin Products Bu_4Sn	Bu_6Sn_2
1	$Bu_3SnAlEt_2$	3:1	CuCN(THF)	-30°C	91	9	quant(0)	6	41
2	$Bu_3SnAlEt_2$[c]	1:1	CuCN(THF)	-30°C	87	13	59(5)	15	15
3	$Bu_3SnAlEt_2$	1:1(inv)	CuCN(THF)	-30°C	80	20	11(82)	0	48
4	$Bu_3SnAlEt_2$	3:1	CuCN(THF,HMPA)	0°C	6	94	56(18)	22	37
5	$Bu_3SnCuLiBr(CH_3)_2S$	1:1	(THF)	-50°C	87	13	64[d]	-	-
6	$Bu_3SnCuLiBr(CH_3)_2S$	1:1	(THF,HMPA)	-50°C	65	35	32(35)	13	9
7	$Bu_3SnCuLiCN$[e]	1:1	(THF)	0°C	18	82	45(19)	-	26
8	$Bu_3SnCuLiCN$[e]	1:1	(THF,HMPA)	0°C	17	83	30(30)	-	24

a) In a typical reaction of $Bu_3SnAlEt_2$ with 2, Bu_3SnLi was prepared from LDA (5mmol) and Bu_3SnH (5mmol) in 5 mL dry THF or THF:HMPA (1:1, v/v) at -30°C; then 0.5 hr later Et_2AlCl was added followed by 2 and finally CuCN (0.16mmol). Further reaction (temperature in Table 1) for 2 hrs was followed by quenching with 1N HCl or saturated NH_4Cl (5 mL) at 0°C and extraction into ether (3x15 mL). b) Vinylstannanes 7 and 8 were isolated by preparative GLPC and identified by ^1H and ^{119}Sn NMR as well as GC/MS. Bu_6Sn_2, Bu_4Sn and Bu_3SnCl were identified by GLPC and GC/MS comparison with authentic samples. Yields were calculated using relative weight response of products vs dodecane internal standard and for 7 and 8 are based on 2 used. c) Half of the theoretical amount of 2 was added, followed by CuCN (5 mol %), then the remaining amount of 2. d) 10% *cis*-1,2-bis(tri-*n*-butylstannyl)-1-alkenes also obtained. e) Prepared from Bu_3SnLi and CuCN (1:1).

Since addition of $Bu_3SnAlEt_2$ to 2 requires catalysis and Cu^{+1} is the best catalyst in terms of yield and regiochemical bias we investigated the addition of tributylstannylcopper reagents $Bu_3SnCuLiBrMe_2S$ (1a) and $Bu_3SnCuLiCN$ (1b) to 2 in THF and THF:HMPA. In agreement with previous work[4b] 1a reacted with 2 in THF to give mostly 7 (Table 1, entry 5) while in THF:HMPA 1a and 2 gave a 2:1 mixture of 7 and 8 (Table 1, entry 6). Suprisingly when 1b was reacted with 2 in THF or THF:HMPA vinylstannane 8 was the major regioisomer (Table 1, entries 7 and 8).

We have also studied the reaction of 1b and 2 in THF at low temperature followed by quenching with methanol or Et_2AlCl at different temperatures (Table 2). For both electrophiles we observed increasing proportions of 8 at the expense of 7 as the temperature of the quenching reaction is increased. A noteworthy observation from Table 2 is that the sterically demanding electrophilic aluminum (Et_2AlCl) is more selective for generation of 7 than proton (CH_3OH). The larger amounts of alkyne encountered in reactions of $Bu_3SnCuLiCN$ and 2 (Table 2) when Et_2AlCl is used as the initial quenching electrophile are ascribed to its reaction with 1b as well as 3 and 4[4c].

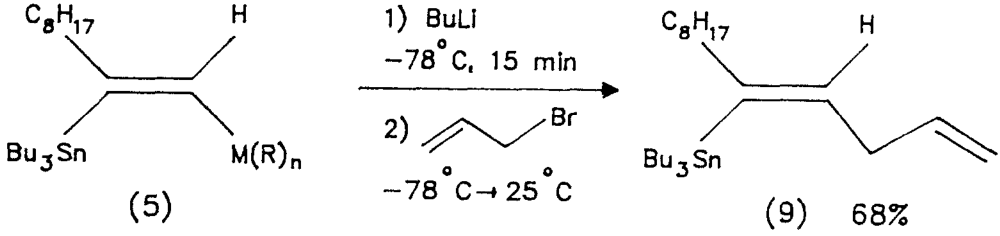
Table 2. Effect of temperature and electrophile on regiochemistry of $Bu_3SnCuLiCN^{a,b}$ addition to 1-decyne.

		Et_2AlCl Quench				Methanol Quench			
Time	Quenching Temperature	7	8	% yield 7 + 8	(alkyne unreacted)	7	8	% yield 7 + 8	(alkyne unreacted)
15 min	-72°C	100	0	68	(31)	90	10	83	(14)
60 min	-50°C	97	3	45	(27)	87	13	51	(20)
100 min	-30°C	87	13	41	(18)	82	18	49	(34)
125 min	0°C	80	20	39	(38)	58	42	56	(15)

a) Prepared from Bu_3SnLi and CuCN(1:1). b) Reagent was prepared in THF at -72°C. After stirring for 15 min, 1-decyne was added and the reaction proceeded another 15 min. One half mL aliquots were withdrawn with a precooled syringe and added to THF solutions (5mL) containing MeOH (3mL) or Et_2AlCl (2mL) at the temperature indicated. Extractive workup using NH_4Cl solution to quench the reaction gave the products identified as in Table 1.

These observations make it apparent that the stannylalumination of alkynes proceeds via reversible stannylcupration[4b,c] to give 3 as the major regioisomeric adduct. At elevated temperatures and in polar aprotic solvents 4 accumulates. According to this view the altered regiochemistry observed when the reaction is conducted in THF:HMPA is due to HMPA complexation of electrophilic aluminum thereby slowing its reaction with 3. Thus the regiochemistry of stannylalumination can be controlled by the proper choice of solvent and electrophilic quenching reagents.

Finally we found that the diethylalane moiety of 5 could be selectivel reacted with n-BuLi without interference from the adjacent tributyltin grour The resulting alkenylalanate derivative was then coupled with allyl bromide t form the corresponding trisubstituted vinylstannane 9 (Scheme 2).



$MR_n = AlEt_2$

Quenching of stannylcopper adducts with electrophilic magnesium and boron proceeds in a similar fashion[10].

References

1. V.S. Zavgarodnii, T.P. Zubova, V.B. Simi and A.A. Petrov, Zh. Obschch. Khim., 51, (1981) 2048.
2. a) J.-I. Hibino, S. Masubara, Y. Marizawa, K. Oshima and H. Nozaki, Tet. Lett., (1984) 2151; b) S. Matsubara, J.-I. Hibino, Y. Mrizawa, K. Oshima and H. Nozaki, J. Organometal. Chem., 285, (1985) 163.
3. J.-I. Hibino, S. Nakatsukasa, K. Fugami, S. Matsubara, K. Oshima and H. Nozaki, J. Am. Chem. Soc., 107, (1985) 6416.
4. a) H. Westmijze, K. Ruitenberg, J. Meijer and P. Vermeer, Tet. Lett., 1982,; b) E. Piers and J.M. Chong, J. Chem. Soc. Chem. Commun., (1983) 934; c) S.D. Cox and F. Wudl, Organometallics, 2, (1983) 184.
5. a) T.N. Mitchell, H. Killing, R. Dicke and R. Wickenkamp, J. Chem. Soc. Chem. Commun., (1985) 354; b) T.N. Mitchell, A. Amamria, H. Killing and D. Rutschow, J. Organometal. Chem., 241, (1983) C45.
6. a) H. Nozaki, K. Wakamatsu, T. Nonaka, W. Tückmantel, K. Oshima and K. Utimoto, Tet. Lett., (1986) 2007. b) H. Hayami, M. Sato, S. Kanemoto, Y. Morizawa, K. Oshima and H. Nozaki, J. Am. Chem. Soc., 105,(1983) 4491; c) Y. Morizawa, H. Oda, K. Oshima and H. Nozaki, Tet. Lett., (1984) 1163.
7. Y. Okuda, K. Wakamatsu, W. Tuckmantel, K. Oshima and H. Nozaki, Tet. Lett., (1985) 4629.
8. a) H. Watanabe, M. Kobayashi, M. Saito and Y. Nagai, J. Organometal. Chem., (1980) 186; b) ibid., 216, (1981) 149.
9. W.C. Still, J. Am. Chem. Soc., 99, (1977) 4836.
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