**Chlorotrimethylstannane**

[1066-45-1]  
\[ \text{C}_3\text{H}_3\text{ClSn} \]  
(MW 199.25)  
InChI = 1/3\text{CH}_3.\text{ClH.Sn/s}^3\text{H}^3;1\text{H}/q;;+1/p-1/3\text{CH}_3.\text{Cl.Sn/h}_3;;\text{h}/q;;-1/\text{m}/\text{c}\text{3H9ClSn/c}1-5(2,3)+/h1-3\text{H}3  
InChiKey = KWT/SZCJWMHPGOS-CEHDEUOCCS  

(starting material for the synthesis of alkyl-, allyl-, alkenyl-, and alkynyltrimethylstannanes and trimethyltin enolates; palladium-catalyzed coupling reactions\(^{14}\))

**Alternate Name:** trimethyltin chloride.  

**Physical Data:** mp 37–39 °C; bp 153–156 °C.  

**Solubility:** sol ether, THF, hexane, CH\(_2\)Cl\(_2\).  

**Form Supplied in:** white solid; widely available.  

**Handling, Storage, and Precautions:** is air stable, but is decomposed by moisture. Commercially available trimethyltin chloride may be used as received. The reagent is very toxic and corrosive, and should be handled with gloves in a fume hood.

**Original Commentary**

Yoshinori Yamamoto  
Tohoku University, Sendai, Japan

**Introduction.** Trimethyltin hydride, cyanide, methoxide, azide, and lithium are prepared from trimethyltin chloride by the procedures similar to those given in *Trimethylchlorostannane*. Similarly, hexamethylditin, bis(trimethyltin) oxide, and diethyldimethyltin oxide are prepared from trimethyltin chloride.

**Organotrimethyltins via Transmetalation.** Lithiated 1,3-dithianes react with trialkyltin or triphenyltin chlorides to form the corresponding 1,3-dithian-2-yltin compounds.\(^1\) The organocopper compound, derived from \(\alpha\)-(dialkoxyboryl)alkylzinc iodide and CuCN·2LiCl, reacts with trimethyltin chloride to afford the \(\alpha\)-boron substituted organotin in 87% yield (eq 1).\(^2\) Accordingly, sulfur- and boron-stabilized organotins are readily converted to the corresponding trimethyltin derivatives.

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\text{R} = \text{Bu, 70%; Me, 72%}
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The intramolecular transfer reaction of lithium 1-alkynyltrialkyborates, prepared in situ from lithium acetylides and trialkylboranes, induced by trimethyltin chloride is highly stereoselective, with the resultant dialkyboryl-substituted alkenylstannanes having the migrating alkyl group trans to the trialkyltin group (eq 5).\(^8\) Conversion of the resulting dialkyboryl group \((R = Et)\) to the alkenylcopper followed by treatment with methanol or alkyl halides produces di- or trisubstituted alkenyltrimethylstannanes, respectively (eq 6).\(^9\) By starting from conjugated terminal enynes, 2-(trimethylstannyl)-1,3-butadienes are similarly synthesized.

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Alkenylstannanes have been utilized for a variety of synthetic applications. The palladium-catalyzed coupling reaction of vinyl triflates and vinyl halides with alkenylstannanes affords 1,3-diienes. The facile transmetalation reaction between alkenylstannanes and alkyllithiums remains as one of the most direct routes to certain alkenyllithium reagents. Treatment of alkenylstannanes with iodine affords the corresponding vinyl iodides with retention of configuration on the vinyl group.

Although the hydrostannylation reaction of alkynes provides a simple route to alkenylstannanes, it is generally not stereoselective. The addition reaction of (trialkylstannyl)copper and related reagents to 1-alkynes and α,β-alkynic esters and amides exhibits high regio- and stereoselectivity. Vinyl triflates and vinyl iodides have also been converted to alkenylstannanes by the reaction with Me₃SnMgMe in the presence of Copper(I) Cyanide catalyst. The hydroalumination of alkynes with Diisobutylaluminum Hydride followed by treatment with Methyl lithium yields alenanes, which are converted to alkenyltrimethylstannanes by addition of trimethyltin chloride (see also Tri-butyllorosstannane). Generally, conversion of vinylalanes to alenanes (ate complexes) is needed to enhance the reactivity toward electrophiles such as Me₃SnCl. The direct transmetalation of vinylalanes to vinylstannanes is accomplished by carrying out the reaction with Me₃SnCl in the presence of LiX (X = Cl, Br, I in DME).

Palladium-catalyzed Reactions. Benzylchlorobis(triphenylphosphine)palladium(II) catalyzes the reaction of acid chlorides with tetraorganotin compounds (Me₃Sn, Ph₃Sn, Ph₃SnMe, Me₂SnCH₂Ph, (PhCH₂)₂Sn, Bu₃Sn, Bu₂SnCH=CH₂, Me₃SnCl) to give ketones in quantitative yields (eq 7). Trimethyltin chloride (1 equiv) also reacts with benzoyl chloride to give acetophenone in quantitative yield, although the reaction takes five times longer to reach completion than the reaction using Tetramethylstannane. By using a trimethyl- or tributylorganotin reagent, the group other than the methyl or butyl groups transfers exclusively in the following order: RC≡C > RCH=CH > aryl > RCH=CHCH₂ ≈ arylCH₂ > MeOCH₂.

Trimethyltin Enolates. Trimethyltin enolates, prepared in situ from lithium enolates and trimethyltin chloride, undergo a rapid aldol condensation with aldehydes to give nearly a 1:1 mixture of the syn and anti aldols in high yields. However, the trimethyltin enolate generated in situ from the lithium enolate of 4-thianone gives the anti aldol with very high diastereoselectivity upon treatment with 2-methylpropanal (eq 9). The lithium enolate itself also provides high anti diastereoselectivity (95:5) in this case.

First Update

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Organotrimethylstannanes via Transmetalation.

Preparation of sp, sp², and sp³ Organostannanes. Lithium–tin exchange is a well-established method for making organostannanes. Recent applications of chlorotrimethylstannane in such exchanges include the treatment of dibromoalkanes (eq 10) or bromoalkynes with butyllithium followed by addition of Me₃SnCl to provide the corresponding alkynylstannanes in good yields.

The palladium-catalyzed coupling of alkynyl iodides with alkynyltrimethylstannanes takes place under mild conditions, stereospecifically and chemoselectively, to give high yields of conjugated enynes (eq 8). Organic groups on tin undergo selective transmetalation with palladium, as shown above, and the alkyne group has the fastest transfer rate of all the organic substituents.

- A list of General Abbreviations appears on the front Endpapers.
An alternative approach to trimethylvinylstannanes involves the chromium-mediated reaction of Me$_3$SnCHBr$_2$ with aldehydes (eq 12). Here, the trimethyl dibromomethylstannane reagent is prepared in the presence of chlorotrimethylstannane. As with many reactions of Me$_3$SnCl, the same process can also be carried out with Bu$_3$SnCl; however, in this chemistry, Bu$_3$SnCHBr$_2$ gave much lower yields of the corresponding vinylstannanes, albeit with improvements in the $E/Z$ product ratios.

Vinyltrimethylstannanes can also be efficiently prepared by Pdcatalyzed hydrostannations of alkynes with trimethyltin hydride generated in situ from the reduction of chlorotrimethylstannane by polymethylhydroxiloxane (PMHS) or Red-Si that have been made hypercoordinate with KF(aq).

Alllyltrimethylstannanes can also be prepared via lithium/tin exchange. Likewise, benzyltrimethylstannanes can be prepared under Barbier conditions by reacting the corresponding benzyl chlorides with Mg(0) and then chlorotrimethylstannane. Such a process has been used in the facile syntheses of benzyl-substituted dihydroisoquinolines and dihydronaphthyridines. For example, a benzylstannane prepared in this manner participated in the dihydroisoquinolines and dihydronaphthyridines. For example, deprotonation of with asymmetric carbanions to afford enantioenriched stannanes. For example, reaction is shown in eq 14. In this case, Me$_3$SnCl was trapped with Me$_3$SnCl to afford stannane with full retention of stereochemistry (eq 15).

Optically active allyltrimethylstannanes can also be made in this way.

Stereochemically pure organostannanes may also be transmetalated with organolithiums. The stereochemical course of such tin–lithium exchanges depends on the conditions and substrates employed, with either retention or inversion of configuration possible. In the case of optically active stannane with (-)-sparteine and then CO$_2$ produces the stereo-inverted enantioenriched amino acid.

Another approach to chiral organostannanes involves the stereospecific asymmetric hydroboration of 1,6-naphthyridine in the presence of ethyl chloroformate (eq 13).

Unactivated organolithiums can also transmetalate with chlorotrimethylstannane. An interesting example of such a reaction is shown in eq 14. In this case, Me$_3$SnCl was trapped by an organolithium species that was generated during the cyclization of an $\alpha$-amino carbanion, which itself came about from the tin–lithium exchange of a tributyltin moiety.

**Preparation and Application of Chiral Organostannanes.**

Transmetalations involving chlorotrimethylstannane have figured prominently in asymmetric syntheses. Chlorotrimethylstannane reacts with asymmetric carbanions to afford enantioenriched stannanes. For example, deprotonation of with n-BuLi/(-)-sparteine proceeds smoothly and the resultant lithium compound can be trapped with Me$_3$SnCl to afford stannane with full retention of stereochemistry (eq 15). Optically active allyltrimethylstannanes can also be made in this way.
Z-allyl trimethylstannane with conservation of the stereogenic center (eq 17).

Finally, the stereospecific transmetalation of cyclopropylmagnesium reagents with chlorotrimethylstannane has also been reported for the preparation of cyclopropylstannanes.\(^{36}\)

**Generation and Reaction of Trimethylstannyl Nucleophiles.** Trimethylstannyl anions can be easily prepared by treatment of chlorotrimethylstannane with Na or Li metal. Such anions are strong nucleophiles, which readily participate in the formation of tin–carbon bonds through a variety of pathways including S\(_{N}\)2 reactions,\(^{37}\) S\(_{N}\)1 reactions (eq 18),\(^{38}\) and halogen–metal exchanges.\(^{39}\)

In **S**tille **R**eactions **C**atalytic in **T**in. As previously discussed, it has been reported that vinyltrimethylstannanes can be efficiently prepared by Pd-catalyzed hydrostannations with trimethyltin hydride that is generated in situ from chlorotrimethylstannane.\(^{25}\) It has also been shown that vinyltrimethylstannanes, so formed, can be used in a one-pot hydrostannation/Stille sequence. Moreover, the trimethyltin halide by-product of the Stille reaction can be recycled back to trimethyltin hydride, thereby rendering the entire process catalytic in tin (eq 19).\(^{40,41}\) It is important to note that Me\(_3\)SnCl is superior to Bu\(_3\)SnCl in this chemistry, as vinyltributylstannanes react too slowly to maintain good catalyst turnover numbers.

Radical-mediated Carboacyclizations. Trimethyltin hydride can also be prepared by the NaBH\(_4\), CN reduction of chlorotrimethylstannane. This combination can be joined with catalytic AIBN to create conditions that will affect radical-mediated carboacyclizations. In this way unactivated dienes or trienes can be transformed to a variety of carbocycles, including tetrahydrofurans, pyrrolidines, etc. (eq 20).\(^{42}\)

In **S**itu **G**eneration and **R**eaction of **T**rimethyltin **A**mides and **E**thers.

Trimethyltin Amides and the Regioselective Bromination of Aromatic Amines. Chlorotrimethylstannane also reacts efficiently with lithium amides to afford trimethyltin amides. This reaction has been employed elegantly in the selective one-pot bromination of amino-substituted arenes and heteroarenes.\(^{43}\) Here, the trimethyltin amide can be made by the treatment of an aromatic amine with \(n\)-BuLi, followed by the addition of Me\(_3\)SnCl (eq 21). The in situ generated N-trimethyltin substituted aromatic amine is then treated with bromine. The trimethyltin moiety appears to create a steric block to orthobromination. As a result, the reactions tend to be highly regioselective in favor of the \(para\) brominated compounds (an exception to this rule is 2-aminonaphthalene, which gave 1-bromo-2-amino naphthalene in 91% yield). At the end of this sequence the reaction mixture is exposed to aq KF, which cleaves the trimethyltin amide to afford the \(para\)-brominated arene.

Trimethyltin Ether-mediated Cyclizations. During their synthesis of amphibinolide K, Williams and Meyer found that stereoselective formation of a 2,3-cis-tetrahydrofuran benefited from the addition of chlorotrimethylstannane to the reaction.\(^{44}\) The role
of this additive is to generate the trimethyltin ether, which maintained the nucleophilicity of the oxygen, thus accelerating the Pd-mediated cyclization and suppressing unwanted intramolecular acyl transfer (eq 22).

\[
\text{Ph-NH}_2 + \text{Me}_3\text{SnCl}, \text{THF} \rightarrow \text{Ph-NH} + \text{Me}_3\text{SnOH}
\]

(21)

Chlorotrimethylstannane as a Lewis Acid in Asymmetric Allylic Alkylation. Chlorotrimethylstannane can serve as a Lewis acid in the asymmetric alkylation of ketone enolates to generate quaternary carbon centers. For example, reaction of ketone 4 with LDA in the presence of a catalytic amount of a chiral palladium complex, allyl acetate, and Me3SnCl affords allylated product 5 in 83% yield and with 95% ee (eq 23).45 Such reactions have proven useful in the total syntheses of hamigeran B46 and allocyathin B.47 It is also worth noting that, while Bu3SnCl can be used in place of Me3SnCl, the reaction yields and enantiomeric excesses tend to be slightly better when Me3SnCl serves as the Lewis acid.

\[
\text{Me}_3\text{SnCl}, \text{LDA}, (\text{S,S})-\text{L}^+ \rightarrow \text{Me}_3\text{SnCl}, \text{LDA}, (\text{S,S})-\text{L}^+ \rightarrow \text{Me}_3\text{SnCl}, \text{LDA}, (\text{S,S})-\text{L}^+
\]

(22)

cis/trans = 8:1


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