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PRELIMINARY COMMUNICATION

Reformatsky-type reactions of α-functionally substituted organotin compounds

The chemical reactivity of the $Sn–\dot{C}$ bond in compounds $R_3Sn\dot{C}H_2X$ (X, functional group with −M effect such as CN or COOEt) and $R_3Sn\dot{C}H_2CH_2X$ (defined as α- and β-functionally substituted, respectively) differs considerably[1] with respect to both nucleophilic reactions such as alkaline hydrolysis[2] or attack by lithium aluminium hydride[3] or Grignard reagents[3] and electrophilic reactions such as cleavage by halogens[4]. Ionic cleavage of the $Sn–\dot{C}$ bond in compounds $R_3Sn\dot{C}H_2X$ is facilitated by the ability of the group X to stabilize negative charge on the adjacent carbon atom (*cf.* ref. 2), *e.g.*:

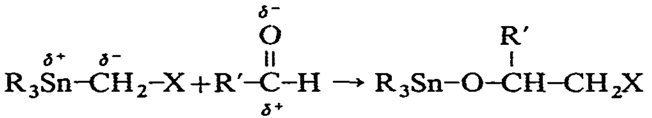
$$\bar{C}H_2–C{\equiv}N \leftrightarrow CH_2{=}C{=}\bar{N}$$

A similar resonance stabilization of an incipient carbanion is not possible for compounds $R_3SnCH_2\dot{C}H_2X$ and, therefore, attack is on X rather than on $Sn–\dot{C}$[2,3].

The extreme susceptibility towards electrophilic attack (*e.g.* by halogen[4]) of compounds R_3SnCH_2X suggested to us that interaction with organic substrates containing strongly electrophilic carbon might enable their synthetic application as carbon-functional chain extension reagents. One isolated example of such a reaction has been reported in the literature, *i.e.* the addition of triethylstannylacetone to benzaldehyde[5].

Quite recently the generation of carbon–carbon bonds via organotin compounds has received attention. Both triethyl(phenylethynyl)tin[6] and triethylallyltin[7] have been added to a few aldehydes and ketones. α-Functionally substituted organotin compounds undergo condensation with both allyl and benzyl bromide[8]. All these reactions have in common that the group transferred from tin to carbon may give rise to a resonance-stabilized carbanion.

In the present communication we wish to report that α-functionally substituted organotin nitriles, ketones, esters and amides readily add across the carbonyl group of a variety of aldehydes and ketones with quantitative formation of the corresponding β-triorganostannoxy-substituted carbon-functional derivatives:



$$\overset{\delta+}{R_3Sn}–\overset{\delta-}{CH_2}–X+R'–\underset{\delta+}{\overset{\overset{\delta-}{O}}{\overset{\|}{C}}}–H \rightarrow R_3Sn–O–\overset{\overset{R'}{|}}{C}H–CH_2X$$

(X = CN, COMe, COOEt, CONEt$_2$)

Representative examples of such reactions have been listed in Table 1.

Since the Sn–O bond of the adducts obtained is easily hydrolyzed under acidic conditions an attractive new route to β-hydroxynitriles, -ketones, -esters and -amides has become available, *e.g.*:

TABLE 1

ADDITION OF α-FUNCTIONALLY SUBSTITUTED ORGANOTINS TO ALDEHYDES AND KETONES

Reaction[a]		Product[b]	Conditions for complete reaction
I	$Bu_3SnCH_2CN + C_6F_5CHO$	$Bu_3SnOCH(C_6F_5)CH_2CN$ B.p., 146–156°/0.1 mm; n_{D}^{20}, 1.4813	16 h, room temp.
II	$Bu_3SnCH_2CN + CCl_3CHO$	$Bu_3SnOCH(CCl_3)CH_2CN$ B.p., 130–133°/0.08 mm; n_{D}^{20}, 1.4995	16 h, room temp.
III	$Et_3SnCH_2COMe + C_6F_5CHO$	$Et_3SnOCH(C_6F_5)CH_2COMe$	Exothermal at room temp.
IV	$Et_3SnCH_2COMe + C_6H_5CHO$[c]	$Et_3SnOCH(C_6H_5)CH_2COMe$	Exothermal at room temp.
V	Et_3SnCH_2COMe + furfural	$Et_3SnOCH(C_4H_3O)CH_2COMe$	Exothermal at room temp.
VI	Et_3SnCH_2COMe + n-PrCHO	Et_3SnOCH(n-Pr)CH_2COMe	Exothermal at room temp.
VII	$Et_3SnCH_2COMe + C_6H_5COCF_3$	$Et_3SnOC(C_6H_5)(CF_3)CH_2COMe$	Exothermal at room temp.
VIII	$Et_3SnCH_2COMe + ClCH_2COCH_2Cl$	$Et_3SnOC(CH_2Cl)_2CH_2COMe$	Exothermal at room temp.
IX	Et_3SnCH_2COMe + cyclohexanone	$C_6H_{10}(Et_3SnO)(MeCOCH_2)$*gem*	48 h, room temp.
X	$Et_3SnCH_2COOEt + C_6F_5CHO$	$Et_3SnOCH(C_6F_5)CH_2COOEt$ B.p., 107–108°/0.07 mm; n_{D}^{20}, 1.4751	16 h, room temp.
XI	$Et_3SnCH_2COOEt + C_6H_5CHO$	$Et_3SnOCH(C_6H_5)CH_2COOEt$	8 h/50°, $ZnCl_2$ cat.
XII	$Et_3SnCH_2COOEt + CCl_3CHO$	$Et_3SnOCH(CCl_3)CH_2COOEt$ B.p., 108–114°/0.25 mm; n_{D}^{20}, 1.4973	Exothermal at room temp.
XIII	$Et_3SnCH_2COOEt + C_6H_5COCF_3$	$Et_3SnOC(C_6H_5)(CF_3)CH_2COOEt$	5 h/60°, $ZnCl_2$ cat.
XIV	$Et_3SnCH_2CONEt_2 + C_6F_5CHO$	$Et_3SnOCH(C_6F_5)CH_2CONEt_2$	Exothermal at room temp.
XV	$Et_3SnCH_2CONEt_2$ + furfural	$Et_3SnOCH(C_4H_3O)CH_2CONEt_2$	4 h/60°
XVI	$Et_3SnCH_2CONEt_2 + CCl_3CHO$	$Et_3SnOCH(CCl_3)CH_2CONEt_2$	Exothermal at room temp.

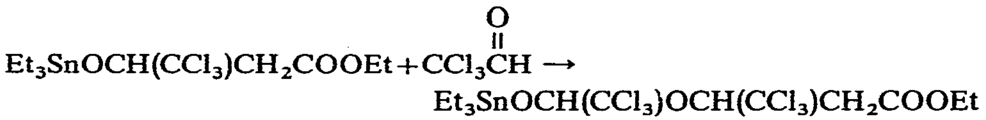
[a] Reactions were carried out by mixing equimolar amounts of the reactants under N_2 in the absence of a solvent. [b] All compounds have been characterized by NMR spectroscopy. [c] *Cf.* ref. 5; the reaction proceeds equally well with *o*- and *p*-chloro-, *m*- and *p*-nitrobenzaldehyde.

$$Bu_3SnCH_2CN + C_6F_5\overset{O}{\overset{\|}{C}}H \rightarrow Bu_3SnO\overset{C_6F_5}{\overset{|}{C}}HCH_2CN \xrightarrow[Et_2O]{HCl} Bu_3SnCl + C_6F_5\overset{OH}{\overset{|}{C}}HCH_2CN$$

m.p., 88–89°

As appears from Table 1 adduct-formation runs to completion under particularly mild conditions if an electron-withdrawing group is attached to the carbonyl group. If necessary the reaction can be catalyzed by Lewis acids (reactions XI and XIII, Table 1; *cf.* ref. 7) suggesting once more that electrophilic attack of the carbonyl carbon on the Sn–C bond is the rate-determining step in these reactions (*cf.* ref. 9).

The 1:1 adduct XII in the presence of excess of chloral affords a 1:2 adduct (*cf.* comparable reactions with trialkyltin hydrides[9] and alkoxides[10]):

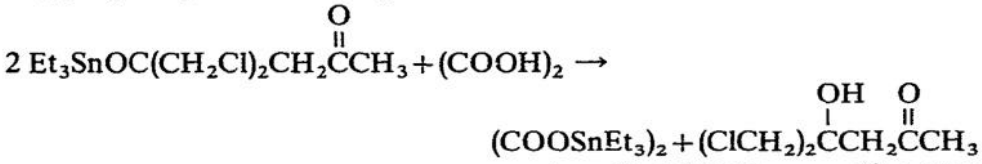


$$Et_3SnOCH(CCl_3)CH_2COOEt + CCl_3\overset{O}{\overset{\|}{C}}H \rightarrow Et_3SnOCH(CCl_3)OCH(CCl_3)CH_2COOEt$$

Although IR spectroscopy is useful, the progress of the additions with aldehydes is more conveniently followed by observing the very characteristic changes in the PMR spectrum. Due to the presence of a centre of asymmetry the spectra of the aldehyde adducts reveal an ABX pattern with eight lines at high field and four lines at low field.

The products listed in Table 1 are high-boiling liquids which cannot be distilled without some decomposition taking place. Since as appears from the PMR spectra, the products formed are better than 98 % pure no further attempts at purification were made.

In order to avoid olefin-forming elimination malonic acid[7] or oxalic acid is preferred over ethereal hydrochloric acid[6] for converting the adducts into the corresponding β-hydroxy derivatives, *e.g.*:



$$2\,Et_3SnOC(CH_2Cl)_2CH_2\overset{O}{\overset{\|}{C}}CH_3 + (COOH)_2 \rightarrow (COOSnEt_3)_2 + (ClCH_2)_2\overset{OH}{\overset{|}{C}}CH_2\overset{O}{\overset{\|}{C}}CH_3$$

b.p., 61–62°/0.05 mm; n_D^{20}, 1.4829

The direct introduction of carbon-functional groups has remained an important problem in organic synthesis (functionally substituted halides are not amenable to Grignard-formation; the Reformatsky-reaction which is often attended by side reactions is largely limited to introduction of the ester function). Therefore, we wish to draw attention to this particularly facile organometallic method of carbon-functional chain extension, the scope of which is the subject of further investigation at our Institute.

Details of this research will be published in the full paper.

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