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## Synthesis of Alcohols via Mild Oxidation of Perfluoroethylstannanes

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Abstract: Alkaline  $H_2O_2$  oxidizes perfluoroethyl-substituted stannanes to the corresponding alcohols with retention of configuration. © 1999 Elsevier Science Ltd. All rights reserved.

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The trialkylstannane moiety participates in a variety of useful synthetic transformations<sup>1</sup> including chemoselective oxidation to carbonyls<sup>2</sup> or their equivalent.<sup>3</sup> Their direct conversion to alcohols, in contrast, has proven more elusive in all but a few structurally restricted cases<sup>4</sup> and generally requires comparatively strong oxidants such as lead tetraacetate<sup>5</sup> or 3-chloroperbenzoic acid (*m*-CPBA).<sup>6</sup> Some alternative, 2-step procedures are also available, e.g., (i) cleavage of an alkyl substituent from the tin using molecular bromine followed by ammoniacal *m*-CPBA<sup>7</sup> or (ii) initial hydroboration of the stannane and oxidation of the resultant borane.<sup>8</sup> Herein, we describe the preparation of perfluoroethyl-substituted<sup>9</sup> stannanes and their direct, stereospecific oxidative transformation to the corresponding alcohols under mild conditions.

The scope of the tin-to-alcohol conversion was explored with a panel of representative perfluoroethyl-substituted stannanes and the results are summarized in Table 1. Since the oxidation of aryltins is often difficult,<sup>8</sup> dibutyl(perfluoroethyl)phenylstannane (1) was used as a model system to evaluate reaction parameters. The best yield of phenol (2) was obtained with slightly alkaline 30%  $H_2O_2$  in methanol/THF at room temperature (Entry 1). Notably, the trialkyl analog of 1, i.e., tributylphenylstannane, completely resisted these conditions and could be recovered quantitatively after 2 days. Reactions of 1 with  $H_2O_2$  were significantly

Entry	Stannane	Solvent	Time (h)	Oxidant/Base	Product	Yield (%)
1	$\sum_{(1)} SnBu_2(\mathbf{R}_f)$	MeOH/THF	14	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	(2) (2)	94
2	1	THF	72	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	2	50 <sup>a</sup>
3	1	THF	2	KO <sub>2</sub>	2	85
4	1	THF/H <sub>2</sub> O	24	NaBO <sub>3</sub>	2	87
5	1	MeOH/THF	15	Oxone	2	0
6	$n-\mathrm{Bu}-\sqrt{-\mathrm{SnBu}_2(\mathbf{R}_f)}$ (3)	MeOH/THF	5 14	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	<i>п</i> -Ви-{)-ОН (4)	90
7	$F - SnBu_2(\mathbf{R_f})$ (5)	MeOH/THF	5 14	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	<b>F-√_</b> ОН ( <b>б</b> )	86
8	$SnBu_2(\mathbf{R}_f)$	MeOH/THF	16	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	(8) OH	85
9	$SnBu_2(\mathbf{R}_f)$ (9)	MeOH/THF	<sup>5</sup> 14	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	OH (10)	68
10	$SnBu_2(\mathbf{R}_f)$ (11)	MeOH/THF	30	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	ОН (12)	38
11	$\underbrace{H}^{H} SnBu_2(\mathbf{R}_{\mathbf{L}})$	MeOH/THF	14	H <sub>2</sub> O <sub>2</sub> /KHCO <sub>3</sub>	(14)	73
<sup>a</sup> Balance is unreacted starting material. $\mathbf{R}_{\mathbf{f}} = CF_3CF_2$ -						

**Table 1. Oxidation of Perfluoroethyl-Substituted Stannanes** 

slower in the absence of base or in non-hydroxylic solvents such as THF (Entry 2). Synthetically useful yields were also achieved utilizing powdered potassium superoxide (Entry 3) or sodium perborate (Entry 4), but not Oxone<sup>®</sup> (Entry 5). Moderate electron donating (Entry 6) and withdrawing groups (Entry 7), represented by 4-butylphenylstannane (3) and 4-fluorophenylstannane (5), respectively, had little influence on the course of the oxidation and gave rise to the corresponding phenols 4 and 6 in good to excellent yields.

Likewise, benzylstannane 7 and secondary alkylstannane 9 were smoothly converted to alcohols 8 and 10, respectively, by the combined actions of  $H_2O_2/KHCO_3$ . On the other hand,

the oxidation of primary alkylstannane **11** to alcohol **12** was sluggish. This is consistent with nucleophilic attack of the peroxide anion at tin (eq. 1) followed by migration of a stannyl-substituent to the electrophilic oxygen center. Aqueous quench and hydrolysis of the newly generated stannyl ether liberates the corresponding alcohol. The poor migratory aptitude<sup>10</sup> of unactivated, primary alkyl groups, together with competition from the other *n*-alkyl substituents on tin, account for the low yield of **12**. Additional evidence in support of the mechanistic hypothesis in equation 1 comes from the observation that chiral (R)-stannane **13** was stereospecifically transformed to (R)-2-octanol (**14**) with virtually complete retention of configuration as determined by chiral phase HPLC<sup>11</sup> and NMR comparisons of the derived Mosher ester versus a standard.



The perfluoroethylstannanes in Table 1 were prepared in good to excellent yields via addition of the appropriate Grignard or lithium reagent to iodide **18** under standard conditions. The latter reagent was conveniently secured (Scheme 1) from commercial (Strem Chem., Inc.) di-*n*-butyldiphenyltin (**15**) by selective phenyl cleavage utilizing molecular iodine to give **16** which was then subjected to nucleophilic displacement with *in situ* generated perfluoroethyllithium.<sup>12</sup> Controlled iodine exchange of the resultant stannane **17** and chromatographic purification provided ready access to **18**.

Scheme 1 *n*-Bu<sub>2</sub>Ph<sub>2</sub>Sn  $\xrightarrow{a}$  *n*-Bu<sub>2</sub>PhSn-I  $\xrightarrow{b}$ 15 *n*-Bu<sub>2</sub>PhSn-CF<sub>2</sub>CF<sub>3</sub>  $\xrightarrow{c}$  *n*-Bu<sub>2</sub>(CF<sub>3</sub>CF<sub>2</sub>)Sn-I 17 *18 a*I<sub>2</sub> (1 equiv), Et<sub>2</sub>O, 0° to 23°C, 12 h.<sup>b</sup>CF<sub>3</sub>CF<sub>2</sub>-I, MeLi, Et<sub>2</sub>O, General Oxidation Procedure: Hydrogen peroxide (aqueous 30%, 5 mmol) was added to a room temperature solution of perfluoroethylstannane (1 mmol) and KHCO<sub>3</sub> (3 mmol) in MeOH/THF (1:1, 8 mL). After stirring for the designated time (Table 1), the reaction mixture was neutralized with 5% HCl, concentrated under reduced pressure, and the residue partitioned between  $Et_2O$  and  $H_2O$ . The combined ethereal extracts were evaporated *in vacuo* and the product purified via SiO<sub>2</sub> chromatography.

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