

Stereoselective Hydrostannation of Diacrylate and Dimethacrylate Esters of Galactaric Acid Derivatives: Cyclohydrostannation vs. Diaddition [†]

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Abstract: This paper reports a study on the free radical hydrostannation of ((4*S*,4'*R*,5*R*,5'*S*)-2,2,2',2'-tetramethyl-[4,4'-bi(1,3-dioxolane)]-5,5'-diyl)bis(diphenyl methylene) diacrylate (**1**) and dimethacrylate (**2**) with triorganotin hydrides, R₃SnH (R = Me, *n*-Bu, Ph). Preliminary investigations show that these reactions could lead to mixtures of products of cyclohydrostannation and/or mono- or diaddition according to the organotin hydrides employed and the reaction conditions used. The addition of Me₃SnH to **1** afforded a mixture of three organotin compounds from which the pure new 13-membered macrodiolide **3** (48%) was obtained. The other two organotins could not be separated. The addition of *n*-Bu₃SnH to diester **1** led to a mixture of two organotins, the one in major proportion (91%) being the product of diaddition **7**. The minor product **6a** (9%) could not be isolated pure. The hydrostannation of **1** with Ph₃SnH led to one organotin: The product of diaddition **8**. The hydrostannation of the dimethacrylate **2** with the organotin hydrides R₃SnH (R = Me, *n*-Bu, Ph) under the same reaction conditions, led in the three cases to mixtures containing mainly diaddition products, and no cyclization products were detected. Some physical characteristics of the new compounds including selected values of ¹H, ¹³C, and ¹¹⁹Sn NMRs are included.

Keywords: hydrostannation; cyclohydrostannation; unsaturated diesters of galactaric acid derivatives

1. Introduction

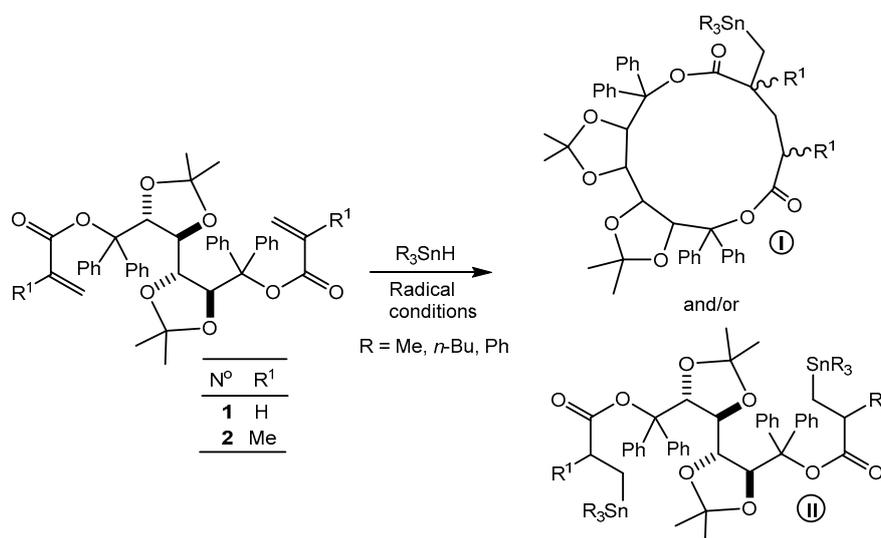
We have already reported a new method that enables the synthesis of 11-membered macrodiolides starting from TADDOL unsaturated diesters via a tandem cyclohydrostannation reaction using triorganotin hydrides and diorganotin chlorohydrides. The new macrocycles were obtained in high global yields and with very good diastereoselectivity [1,2]. We also studied the effect of changing the number and the steric volume of the substituents on the structure of the reaction products, i.e., macrocycles and/or diaddition products [3]. In order to determine the effect of the length of the starting unsaturated diesters on the nature of the products, we considered it of interest to study the addition of organotin hydrides to unsaturated diesters derived from D-(+)-galactose. Now, the preliminary results of these investigations are described.

2. Results and Discussion

Taking into account our previous results, the addition under free radical conditions of triorganotin hydrides (R_3SnH) to ((4*S*,4'*R*,5*R*,5'*S*)-2,2,2',2'-tetramethyl-[4,4'-bi(1,3-dioxolane)]-5,5'-diyl)bis(diphenyl methylene) diacrylate (**1**) and dimethacrylate (**2**) could lead to products of cyclohydrostannation (**I**) and/or diaddition (**II**), as shown in Scheme 1.

The hydrostannation of unsaturated diesters **1** and **2** with organotin hydrides R_3SnH ($R = Me, n-Bu, Ph$), was carried out under argon, at 75 °C, with stirring, in toluene and, in one case, without solvent, using azo-bis-isobutyronitrile (AIBN) or UV radiation as radical initiators. The reactions were followed by IR (observing the disappearance of the Sn–H absorption) and 1H NMR spectroscopy (observing olefin disappearance and product formation). In all cases, the optimum times of reactions and hydride/olefin ratios required for a quantitative yield (with respect to olefin) were determined.

The addition of Me_3SnH in THF to diester **1**, at 75 °C, using a ratio tin hydride/**1** = 2.1 led, after 12 h of reaction, to a mixture of three organotin compounds as shown by the ^{119}Sn NMR spectroscopic analysis. Due to the fact that with this substrate the cyclohydrostannation should lead to the creation of one new stereogenic center, a maximum of two diastereomers were expected.



Scheme 1. Radical hydrostannation of unsaturated diesters **1** and **2**.

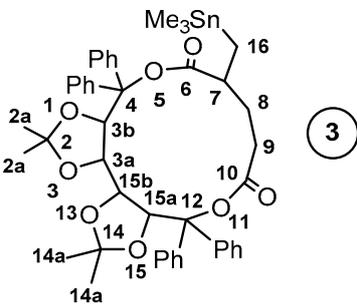
The ^{119}Sn NMR spectrum of the mixture showed a resonance at -3.34 ppm (48%), another at 0.07 ppm (20%), and a third signal at 5.64 ppm (32%). The compound in higher proportion was separated pure by column chromatography using silica gel 60 as adsorbent. The NMR analysis together with FTIR data (see Table 1) and elemental analysis clearly showed that the major product was the macrocycle **3** (see Table 1). Thus, as seen in Table 1, the ^{13}C NMR spectrum shows the existence of two carbonyl groups (C-6 and C-10), one of them with a $^3J(C, Sn)$ coupling constant (C-6). The presence of the two carbonyls was confirmed by the FTIR spectrum, which shows two peaks ν_{CO} : 1760 and 1732 cm^{-1} . The other two organotins present in the crude product could not be obtained pure. They probably are products of addition (type II, Scheme 1).

On the other hand, the addition of Me_3SnH to dimethacrylate **2** led to a mixture of two organotins; the ^{119}Sn NMR spectrum showing two signals at -0.8 and 1.5 ppm. The presence in the ^{13}C NMR spectrum of four carbonyl signals at $164.88, 164.93, 175.29,$ and 175.39 ppm strongly suggests that both compounds are the macrocycle products of cyclohydrostannation. Unfortunately, we were not able to obtain these compounds pure.

We then carried out the additions of $n-Bu_3SnH$ and Ph_3SnH to diacrylate **1** and dimethacrylate **2** using the same protocol. These additions followed a different pattern. The ^{119}Sn NMR spectroscopic analysis of the crude products obtained in these additions showed, in all cases, the formation of

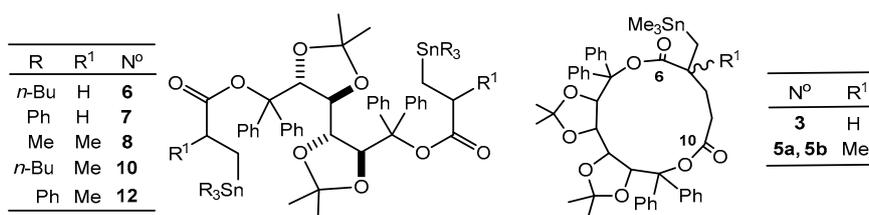
mixtures of various organotins. A summary of the results obtained and some other information are included in Table 2.

Table 1. Some FTIR, ¹H, ¹³C, and ¹¹⁹Sn NMR spectroscopic data of compound 3.

	¹³ C NMR ^a (ppm) (CDCl ₃)	Me-Sn -8.75 (33.4)	C-6 172.99 (39.9)	C-7 53.58 (NO)	C-8 31.73 (41.0)	C-10 171.63	C-16 15.33 (341.4)
	¹ H NMR (ppm) (CDCl ₃)	-0.08 (d, 2H); 0.00 [s, 9H, ² J(Sn, H) = 52.4 Hz]; 0.68–1.06 (m, 3H); 1.19 (s, 6H); 1.28 (s, 6H); 1.87–2.35 (m, 1H); 3.25–3.50 (m, 1H); 4.75–4.94 (m, 1H); 4.99–5.39 (m, 1H); 5.89 (s, 2H); 6.90–7.70 (m, 20H).					
	¹¹⁹ Sn NMR (ppm) (CDCl ₃)	-3.34					
	FTIR (cm ⁻¹) (Nujol)	1760.05; 1732.63.					
	^a [^ν]/(C, Sn) in Hz.						

Hydrostannation of unsaturated diester 1 with *n*-Bu₃SnH afforded a mixture of two organotins (Table 2). The compound in higher proportion in the mixture is the product of diaddition 5 (91%), which we could not separate pure. Similarly, the addition of Ph₃SnH led to just one organotin: The product of diaddition 7, as shown in Table 2.

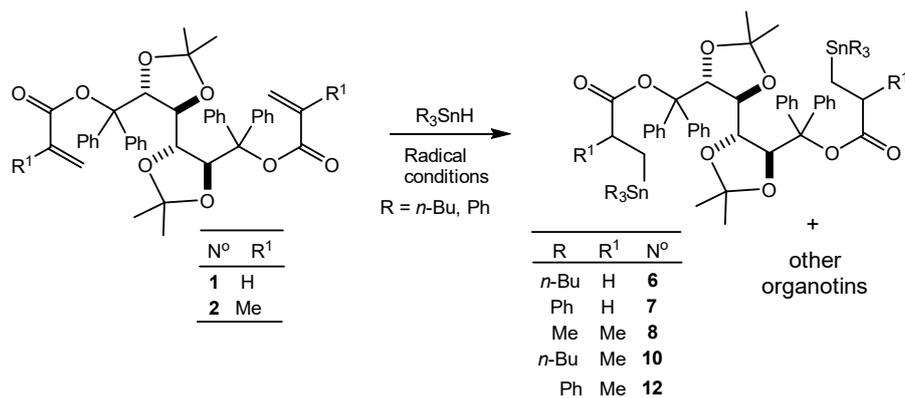
Table 2. Triorganotin hydride additions to unsaturated diesters 1 and 2^a.



Reaction N ^o	R	Ester N ^o	Time (h)	Adduct N ^o ^b	¹¹⁹ Sn NMR (ppm) ^c	% in the Mixture	¹³ C NMR C=O (ppm)	
							C-6	C-10
Me	Me	1		3	-3.34	48		
				4a	-0.1	20	171.63	172.99
				4b	5.6	32		
2	Me	2	16	5a	-0.8	73	164.88	164.93
				5b	1.5	27	175.29	175.39
3 ^d	<i>n</i> -Bu	1	1	6a	-8.0	9	173.04 (64.5)	
				7	-7.8	91		
4	Ph	1	3	8	-98.2	100	172.56 (77.2)	
				9	-12.0	60	174.84	
5	<i>n</i> -Bu	2	1	10a	-9.9	20	175.17	
				10b	-9.6	20	175.30	
				11	-104.0	75	174.73	
6	Ph	2	3	12a	-101.0	12.5	174.88	
				12b	-100.8	12.5	175.03	

^a The reactions were carried out in toluene, at 75 °C, using AIBN as radical initiator except when otherwise indicated. ^b The compounds with numbers and letters could not be obtained pure. Compounds with just a number indicate that the compound is either pure or that the structure is clearly supported by spectroscopy. ^c In CDCl₃; chemical shifts in ppm with respect to Me₄Sn. ^d Reaction carried out without solvent.

On the other hand, the additions of *n*-Bu₃SnH and Ph₃SnH to dimethacrylate 2, led in all cases to products of diaddition (Table 2 and Scheme 2).



Scheme 2. Radical hydrostannation of unsaturated diesters **1** and **2**.

The presence in the ¹³C NMR spectra of carbonyl groups around 173 ppm (none below 170 ppm) supports that these compounds are the products of diaddition.

The results obtained so far demonstrate that the products of these radical additions depend on the nature of the substituents at the tin atom of the triorganotin hydrides. In the case of the Me₃SnH, the hydride addition would favor the operation of the cyclohydrostannation tandem radical mechanism.

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Conflicts of Interest: The authors declare no conflict of interest.

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