Table I. Stereochemistry of the Bromodemetalation of *sec*-Butyltrialkyltin Compounds in Methanol–Cyclohexane

sec-BuSnR$_3$ (% optical purity)	*sec*-BuBr[a] (% optical purity)	Predominant stereochemistry (% stereospecificity)
(R)-(−)-*sec*-BuSn(i-Pr)$_3$ (75)	R (−) (34)	Retention (45)
(+)-(*sec*-Bu)$_4$Sn[b]	S (+) (7.5)	Retention (ca. 35[c])
(R)-(−)-*sec*-BuSn(3-pentyl)$_3$ (25)	R (−) (2)	Retention (8)
(S)-(+)-*sec*-BuSn(neopentyl)$_3$ (25)	R (−) (7)	Inversion (28)

[a] The maximum optical rotation has been taken as $[\alpha]^{22}\text{D}$ 34.2°.[10] [b] Obtained from (S)-(+)-*sec*-butyltriphenyltin (86% optical purity) as a mixture of three diastereoisomers.[11] [c] See note[11] for the significance of this value, which might be not very accurate.

tention of configuration, while the closed transition state III,[9] in which bond-making and breaking are not necessarily synchronous[15] (therefore developing charges and possible stabilization by solvent), will lead to retention.

Molecular models show clearly that front-side approach to the carbon by the halogen (II) is progressively hindered when R groups on tin are made bulkier.[16] Moreover, due to its steric requirements, a neopentyl group is much more reluctant to occupy an apical position (III) than a *sec*-butyl group (I). It is thus understandable that *sec*-butyltrineopentyltin will lead to a predominant inversion of configuration at carbon. With smaller R groups, the interactions are less severe and retention of configuration could be preferred on energetics grounds. Methyl or ethyl groups, too easily cleaved to be used in this study, should induce even more predominant retention mechanisms.

The data presented herein suggest that retention of configuration probably is the main stereochemical course of the bromodemetalation of tetraalkyltins in the presence of methanol.[17] In special cases, steric requirements would induce a predominant inversion mechanism.

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(4) The starting materials were obtained from optically active *sec*-butyltriphenyltin,[5] of known optical purity,[6] by cleavage of phenyl groups with HCl–MeOH followed by substitution with appropriate Grignard reagents and thus their maximum optical rotations are known. However, the 9.8° value reported earlier for the trineopentyl derivative[6] has been found to be erroneous, accurate determinations giving now 3.0°. Absolute configurations have received recent experimental support.[7]

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(8) The initial concentration was about 0.9 M for the tetraalkyltin to which a stoichiometric amount of 0.8 M bromine was added. ^{13}C and ^{119}Sn NMR spectra showed that the cleavages were quantitative. No residual tetraalkyltin or dihalogenated organotins were detected (amounts over 3% would have been observed). Quantitative yields for alkyl bromides were confirmed by GLC of the crude mixtures. Alkyl bromides were distilled together with solvents, then the methanol was removed with $CaCl_2$. Optical rotations were measured in cyclohexane after further GLC determination.

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(11) Symbolizing the chiral centers as R and S, Ph_3SnS should lead,[4] in absence of asymetric induction, to a mixture of three diastereoisomers: SnS_4 (0.125), optically inactive SnR_2S_2 (0.375), and both enantiomers $SnRS_3$ (0.375) and $SnSR_3$ (0.125). ^{119}Sn NMR analysis shows that the isomers are present in the above ratio, before and after limited brominolysis, indicating that the diastereoisomers react at very similar rates. With the likely hypothesis that bromine would remove R or S from $SnRS_3$ (and $SnSR_3$) at similar rates, the cleavage of a mixture obtained from optically pure Ph_3SnS should lead to sec-butylbromide with a 25% maximum optical purity.

(12) Control experiments have shown that under the conditions of the demetalation (in the presence of trialkyltin bromide[13] and methanol) as well as during the workup, *sec*-butyl bromide does not undergo racemization. Moreover the presence of methanol and the absence of light is intended to prevent major contribution by a radical cleavage mechanism.[3,14]

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(17) It might be of value to note that even in chlorobenzene, a solvent reported to favor a closed transition state such as III, but probably without developing much charge,[9] we observed a slight preference for inversion of configuration (2%), starting from *sec*-butyltrineopentyltin. However, in this solvent polybromination[12] and radical pathways[14] can no longer be excluded.

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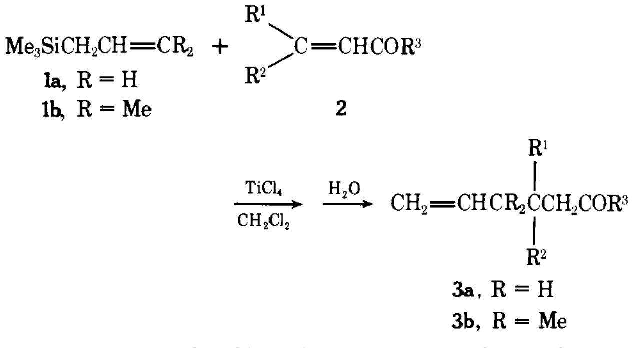
Conjugate Addition of Allylsilanes to α,β-Enones. A New Method of Stereoselective Introduction of the Angular Allyl Group in Fused Cyclic α,β-Enones[1]

Sir:

Allylsilanes are interesting synthetic intermediates with highly nucleophilic double bonds,[2] and recently we have demonstrated that the allyl transfer reaction takes place very smoothly from allylsilanes to carbonyl compounds[3a] and acetals,[3b] with regiospecific transposition of the allylic part, to afford homoallyl alcohols and homoallyl ethers, respectively. Titanium chloride is the most effective activator of the reaction among various Lewis acids.

In this paper, we show the allylation reaction can be applied successfully to α,β-enones to give δ,ε-enones. The most important fact of the findings may be that the allyl group can be introduced at the angular position of a fused cyclic α,β-enone, selectively in high yield.

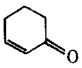
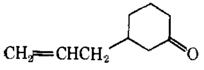
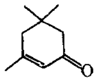
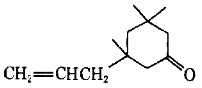
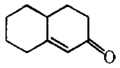
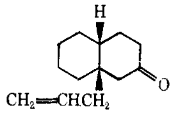


$$Me_3SiCH_2CH{=}CR_2 + (R^1)(R^2)C{=}CHCOR^3 \xrightarrow[CH_2Cl_2]{TiCl_4} \xrightarrow{H_2O} CH_2{=}CHCR_2C(R^1)(R^2)CH_2COR^3$$

1a, R = H
1b, R = Me
2
3a, R = H
3b, R = Me

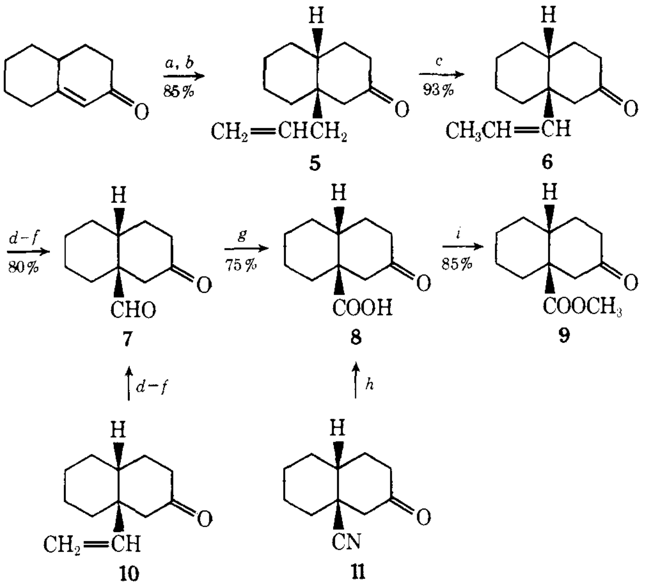
The results are listed in Table I. As a general procedure, to a solution of an α,β-enone (2 mmol) in dry dichloromethane (3 mL) under nitrogen was added titanium tetrachloride (2 mmol) dropwise with a syringe. After additional stirring for 5 min, an allylsilane (2.2 mmol) in dichloromethane (3 mL) was added from a dropping funnel at a temperature indicated in the table and the mixture was stirred for 3 h. Water was added to the mixture which was subsequently extracted with ether. The organic layer was washed with water, dried over sodium sulfate, and concentrated at reduced pressure. The residue was subjected to silica gel column chromatography, yielding a δ,ε-enone. The products were mostly pure enough to give correct analyses and were characterized by GLC,

Table I. Reaction of Allylsilanes with α,β-Enones in the Presence of Titanium Tetrachloride in Dichloromethane[a,b]

Entry	Allylsilane	α,β-Enone	Reaction condition	Product (% yield)[a]
1	1a	$CH_2{=}CHCOCH_3$	−78 °C, 1 min	$CH_2{=}CH(CH_2)_3COCH_3$ (59)
2	1b	$CH_2{=}CHCOCH_3$	−78 °C, 3 h	$CH_2{=}CHC(CH_3)_2CH_2CH_2COCH_3$ (79)
3	1a	$(CH_3)_2C{=}CHCOCH_3$	RT, 5 min	$CH_2{=}CHCH_2C(CH_3)_2CH_2COCH_3$ (87)
4	1a	$(CH_3)_2C{=}CHCOCH_3$	−78 °C, 30 min	$CH_2{=}CHCH_2C(CH_3)_2CH_2COCH_3$ (81)
5	1a	$PhCH{=}CHCOPh$	RT, 1 min	$CH_2{=}CHCH_2CH(Ph)CH_2COPh$ (96)
6	1a		−78 °C, 1 h then −30 °C, 20 min	 (82)
7	1a		−30 °C, 20 min	 (76)
8	1a		−78 °C, 18 h then −30 °C, 5 h	 (85)

[a] Yields of isolated and purified materials. [b] Yields are not always optimized.

Scheme I



[a] $(CH_3)_3SiCH_2CH{=}CH_2$, $TiCl_4$, CH_2Cl_2. [b] H_2O. [c] $(PhCN)_2PdCl_2$, PhH, reflux. [d] O_3, CH_2Cl_2, −78 °C. [e] NaI, CH_3COOH–MeOH. [f] $NaHSO_3$. [g] Ag_2O, aqueous KOH. [h] Aqueous HCl, reflux. [i] CH_2N_2.

NMR, IR, and mass spectra. Yield of the product is usually most satisfactory with titanium tetrachloride as a Lewis acid catalyst of the reaction. α,β-Unsaturated esters such as methyl acrylate and methyl methacrylate did not enter the reaction.

Examination of the examples in Table I reveals that this new conjugate allylation of α,β-enones has much in its generality. The regiospecific transposition in the allylic part was observed in a similar fashion as the cases of the reaction with aldehydes,[2a] ketones,[2a] and acetals[2b] as shown in entry 2.

This reaction provides the first instance of stereoselective direct introduction of the angular allyl group to a fused cyclic α,β-enone (entry 8). Introduction of angular functional substituents in fused cyclic compounds[4–7] is generally an important key-step for synthesis, and conjugate addition of a nucleophilic reagent to an α,β-unsaturated carbonyl function, if it is a stereoselective process, should be very important for the synthesis of naturally occurring compounds.[8] However, no successful report concerning angular allyl grouping has appeared regardless of its attempt.[9]

Addition of 1.4 mole equiv of **1a** to the mixture of $\Delta^{1,9}$-2-octalone (**4**) and an equimolar amount of titanium tetrachloride in dichloromethane at −78 °C resulted in an exothermic reaction. After stirring for 18 h at −78 °C and then for an additional 5 h at −30 °C, hydrolysis and extractive workup followed by distillation gave a single β-allylated ketone, **5**, bp 120 °C (5 mm) in 85% yield. The cis junction of **5** was established by the structural correlation outlined in Scheme I in which derivatives from **5** are identified with known substances prepared from the known starting materials, **10**[8f] and **11**.[7h]

Isomerization[10] of **5** catalyzed by $PdCl_2(PhCN)_2$ in benzene at reflux gave the propenyl derivative (**6**),[11,12] bp 110–113 °C (5 mm), in 93% yield which was thoroughly ozonized in dichloromethane at −78 °C and the resulting mixture was reduced with sodium iodide in MeOH-AcOH at 0 °C to produce the keto aldehyde (**7**),[11] homogeneous by thin-layer (TLC) and gas chromatographic (GLC) analysis, in 80% overall yield from **6**. **7** was identified with the anthentic sample derived from *cis*-9-vinyl-2-decalone (**10**).[8f] Oxidation of **7** using silver oxide-aqueous potassium hydroxide afforded the keto acid (**8**) in 75% yield which was esterified with diazomethane. Both the keto acid (**8**) and the keto ester (**9**) are known.[7h]

The methology reported here for the fused cyclic α,β-enone leads to compounds which are otherwise relatively inaccessible. Related works are now in progress.

Acknowledgment. We thank Toshiba Silicone Co., Ltd., for a gift of chlorosilanes.

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(11) Satisfactory NMR, IR, and mass spectra and elemental analyses were obtained for this material.

(12) A cis isomer was not detected by NMR spectroscopic analysis.

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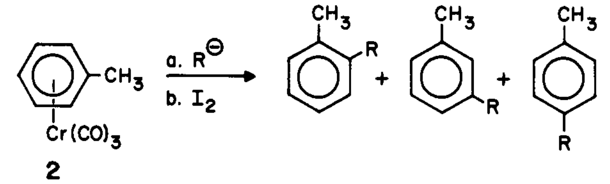
Meta-Substituted Aromatics by Carbanion Attack on π-Anisole and π-Toluenechromium Tricarbonyl

Sir:

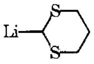
The addition of carbanions to η^6-benzenetricarbonylchromium(0) proceeds under mild conditions to produce a η^5-(alkylcyclohexadienyl)tricarbonylchromium(0) complex which can be oxidized to form the alkylbenzene.[1] This formal substitution for hydride may have special potential in the synthesis of aromatic derivatives because the activating unit [Cr(CO)$_3$] is easily attached and removed, and because existing methods[2] of nucleophilic aromatic substitution generally require a halogen or other electronegative atom at the site of substitution. Since arene substrates will generally bear more than one hydrogen substituent, important questions arise as to whether useful regioselectivity can be attained and what the factors are which influence the site of attack.[3] Here we report preliminary studies of the reaction of carbanions with complex **1**, η^6-anisoletricarbonylchromium(0),[6] complex **2**, η^6-toluenetricarbonylchromium(0),[7] and the complexes (**3**, **4**, **5**)[8] of the dimethoxybenzenes. The results provide evidence of useful selectivities and some hints concerning the mechanism of the reactions.

The results of the reaction of η^6-toluenetricarbonylchromium (**2**) with a variety of carbanions are displayed in Table I. In each case, equimolar amounts of anion (prepared according to standard procedures) and complex **1** were mixed at −78 °C or lower under argon in tetrahydrofuran or in a mixture of THF with hexamethylphosphoric triamide (HMPA). After a short time at 0 °C or below, excess iodine was added and the mixture was stirred at 25 °C for 3-4 h. Conventional isolation procedures produced a crude product which was flash distilled and carefully analyzed using quantitative GLC with an internal standard. Except as noted, all products were prepared in pure form by unambiguous independent routes and were used to calibrate the GLC analysis. The distribution of products depends on the nature of the anion, except for a consistent absence of para substitution. Entries 2, 3, and 4 show that there is little effect of reaction temperature on the distribution of products and that conversion is complete after a few minutes at −78 °C. With cyano- and carboalkoxy-stabilized carbanions, there is a preference toward meta substitution which increases as the size of the carbanion unit increases. Lithio-1,3-dithiane (entry 7) is much less selective, producing almost equal amounts of 1,2- and 1,3-substituted products.

Table I. Reactions of Complex 2 with Carbanions

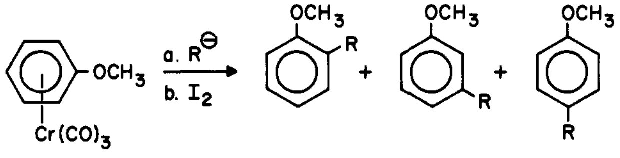


2

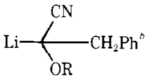
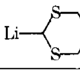
Carbanion	Time (min)/ temp (°C)	Product mixture Ortho	Meta	Para	Combined yield (%)
1. $LiCH_2CN$	5/−78[a]	35	63	2	88
2. $LiC(CH_3)_2CN$	1.5/−100	2	96	2	52
3. $LiC(CH_3)_2CN$	1.5/−78	1	97	2	95
4. $LiC(CH_3)_2CN$	20/0	1	97	2	86
5. $LiCH_2CO_2$-*t*-Bu	15/0[b]	28	72	0	89
6. $LiC(CH_3)_2CO_2$-*t*-Bu	10/0	3	97	0	96
7. 	15/0	52	46	2	94

[a] The medium was a mixture of THF/HMPA, 12.5/1. [b] The medium was an equivolume mixture of THF and HMPA.

Table II. Reaction of Complex 1 with Carbanions[a]



1

Carbanion	Medium	Product distribution Ortho	Meta	Para	Combined yield (%)
1. $LiCH_2CN$	THF	3	97	0	38
2. $LiC(CH_3)_2CN$	THF	3	97	0	93
3. $LiCH_2CO_2$-*t*-Bu	THF/HMPA	6	94	0	86
4. $LiCH(CH_3)CO_2$-*t*-Bu	THF/HMPA	4	96	0	93
5. $LiC(CH_3)_2CO_2$-*t*-Bu	THF/HMPA	0	100	0	76
6.  $Li{-}\overset{CN}{\underset{OR}{C}}{-}CH_2Ph$[b]	THF/HMPA	0	100[b]	0	75
7. 	THF	10	90	0	35

[a] The complex was added to the carbanion at −78 °C and held at 0 °C for 15 min before quenching with excess iodine. [b] The product is benzyl (*m*-methoxyphenyl) ketone, identified by comparison of the melting point of the semicarbazone derivative; cf. J. Levy and R. Pernot, *Bull. Chem. Soc. Fr.*, 49, 1730, 1734 (1931). It is homogeneous by GLC and ^{1}H NMR. R = $CH(CH_3)OCH_2CH_3$; see ref 10.

The results of the reactions of η^6-(anisole)tricarbonylchromium (**1**) with a similar collection of anions are presented in Table II. The anisole complex is somewhat less reactive than complex **2**, and HMPA in the reaction medium is important in order to achieve complete conversion with ester enolates. For entry 6, the isolation procedures include acid and base hydrolysis,[10] and the yield refers to the overall process, resulting in completely selective formation of benzyl (*m*-methoxyphenyl) ketone. Just as with complex **2**, substitution in the para position of complex **1** is apparently not favored; ortho substitution is also disfavored even with the less bulky anions (entries 1 and 3). Very reactive anions such as 2-lithio-1,3-dithiane (entry 7) gives predominant meta substitution, but the yields are low due to competitive proton abstraction, presumably from the ortho position of complex **1**.[11]

Dialkoxyarene ligands appear to be somewhat less reactive than anisole, but smooth additions are achieved using nitrile-