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On the Conjugate Addition of Tetraorganothallium Ate Complexes ¥

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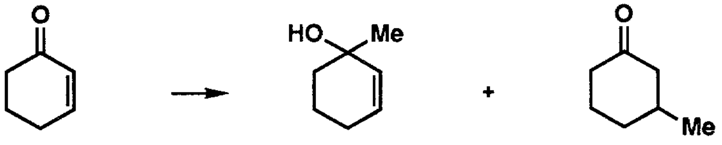
¥ Dedicated fondly to Dr Robert Kennedy for his continuous encouragements

Abstract: *Tetraorganothallium ate complexes have been prepared and reacted with enones to afford either the [1,2] or [1,4] addition product. Mixed ate complexes display high levels of chemoselectivity in the transfer of one of their ligands.*

Triorganothallium (TOT) compounds, readily prepared *in situ* by the reaction of a diorganothallium (DOT) halide with a Grignard or an organolithium reagent,[1] are highly reactive organometallics. Although a large number of TOT derivatives have been prepared in the early part of this century, their synthetic potential has remained virtually unexplored.[2]



1 2 3

Me_3Tl / Et_2O / 20°C		-		P[(a)]
Me_3Tl / Et_2O / -40°C		-		NR[(b)]
$Me_3Tl.MeLi$ / Et_2O / 0°C	1	:	2	75%
$Me_3Tl.MeLi$ / Et_2O / -40°C	<5	:	>95	70%

(a) Polymerisation of the starting enone was observed.

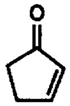
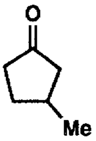
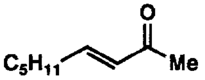
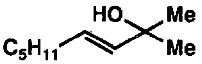
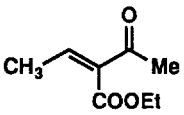
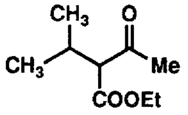
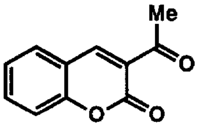
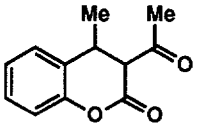
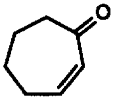
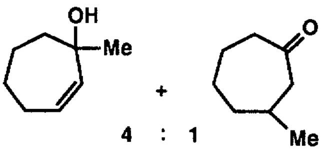
Figure 1 (b) No reaction took place and cyclohexenone was recovered unchanged.

We have previously reported on the smooth and efficient transformation of acid chlorides into ketones, using various TOT derivatives.[3] More recently, we have shown that TOT compounds reacted, both stoichiometrically [4] and catalytically,[5] with activated tertiary and secondary halides. These procedures possess several advantages over pre-existing methodologies, the most noteworthy being **the easy recovery (in almost quantitative yield) of the starting DOT halide which can be recycled several times.**

In this Letter, we describe our preliminary results on the preparation of some of the first organothallium ate complexes [6] and on their reactions with enones.

Our initial attempts to react trimethylthallium with cyclohexenone 1 were frustrated by the rapid polymerisation of this enone in the presence of the thallium reagent, at 20°C, (Figure 1, entry 1) or by its total lack of reactivity at a lower temperature (Figure 1, entry 2). Addition of 1 equivalent of methyllithium to trimethylthallium generated *in situ* the ate complex. Condensation of this reagent with cyclohexenone, at room temperature, afforded a 1:2 mixture of the [1,2] and [1,4] addition products **2** and **3** respectively (Figure 1, entry 3). When the reaction was performed at -40°C, only the conjugate addition product, 3-methyl cyclohexanone **3**, was produced in excellent yield (Figure 1, entry 4).

Table 1. Reaction of Lithium Tetramethyl Thallium with Selected Enones[7]

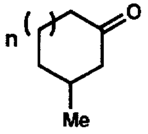
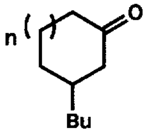
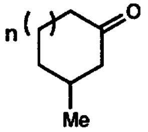
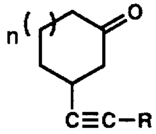
Entry	Substrate	Product	Yields(a)
1			73%
2			81%
3			85%
4			70%
5			80%

(a) = All reactions were carried out using 1.1 equivalent of Me_4TlLi in ether, at - 40°C, for 1h.

The reactions of lithium tetramethylthallate with some representative enones are collected in Table 1 and deserve some comments. Whereas conjugate addition is solely observed in the cases of cyclopentenone (Table 1, entry 1) and cyclohexenone (Figure 1, entry 4), cycloheptenone affords a 4:1 mixture of [1,2] and [1,4] adducts respectively (Table 1, entry 5), a behaviour most difficult to rationalise. In sharp contrast to 5- and 6-membered cyclic enones, acyclic *E*-enones undergo exclusive [1,2] addition (Table 1, entry 2). However, a second electron-withdrawing group on the α-carbon of the acyclic enone, completely shifts the preference for attack on the carbonyl group and only the Michael adducts are formed (Table 1, entries 3 and 4). It is noteworthy that coumarin does not react with lithium tetramethylthallate whereas acetyl coumarin undergoes smooth [1,4] addition (Table 1, entry 4).[8]

With these encouraging results in hand, we next investigated the behaviour of mixed organothallium ate complexes. Some pertinent results are presented in Table 2.

Table 2. Reaction of Mixed Ate Complexes With Enones [7]

Reagent		Products				Yields$^{(a)}$
						
$Me_3Tl.1BuLi$	(n = 1)	1	:	1.4		70%
$Me_2TlCl.2BuLi$	(n = 1)	1	:	8		65%
$Me_2TlCl.2BuLi$	(n = 0)	1	:	9		69%
						
$Me_2TlCl.2\,LiC{\equiv}C{-}R$	(n = 1)	1	:	100	R = Ph	60%
$Me_3Tl.1LiC{\equiv}C{-}R$	(n = 1)	1	:	100	R = Ph	70%
$Me_3Tl.1LiC{\equiv}C{-}R$	(n = 1)	1	:	100	$R = C_5H_{11}$	65%
$Me_3Tl.1LiC{\equiv}C{-}R$	(n = 0)	1	:	100	$R = C_5H_{11}$	55%

(a) = All reactions were performed in ether, at -40°C, using 1.1 eq. of the complex.

Two different types of mixed methyl butyl ate complexes were prepared from the readily available [3] dimethyl thallium chloride: Me_3TlBu[9a] and Me_2TlBu_2.[9b] **Remarkably, both complexes deliver preferentially the butyl ligand.** In the case of the former thallium compound, a 1:1.4 ratio of Me *vs* Bu transfer was observed. This product ratio corresponds to a 4.2:1 preference for butyl exchange. Greater chemoselectivity was observed with Me_2TlBu_2, resulting in a respectable 8-9:1 product ratio, again favouring the butyl transfer (Table 2, entries 2 and 3). An even more dramatic selectivity is found in the reaction of thallium ate complexes containing mixed alkyl-acetylenic moieties (Table 2, entries 4 to 7). In these cases, and regardless of the number of alkyne substituents present in the ate complex, **only the acetylenic ligand is delivered to the enone** and no competing methyl group transfer could be detected.

This observation is highly unusual. Indeed, organocopper reagents retain most tenaciously their acetylenic ligands [10] whereas acetylenic alanes [11] and boranes [12] only react in a Michael fashion with enones capable of attaining an *S-cis* conformation.[13] Cyclic enones such as cyclopentenone and cyclohexenone, which exist in the *S-trans* conformation react with alanes and boranes to afford only the corresponding tertiary carbinol. Mixed tetraorganothallates react with cyclic enones in exactly the opposite manner.

In summary, we have shown for the first time that tetraorganothallium ate complexes can be prepared readily and react with enones to afford either the Michael addition product or the tertiary carbinol. This preference depends upon the nature of the substrate. Mixed tetraorganothallates chemoselectively transfer one of their ligands, with the methyl group being the least exchangeable. Alkynes are smoothly transfered, in sharp contrast to other organometallic reagents.[14]

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References and Notes

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6. The preparation of $KTl(C\quad CH)_4$ has been reported previously: Nast, R.; Kab, K. *J. Organomet. Chem.*, **1966**, *6*, 456.
7. All yields are based on pure materials isolated by chromatography on silica.
8. Tetraorganothallates proved to be extremely sensitive to steric hindrance. For example, carvone produces a 1:2 ratio of [1,2] / [1,4] adducts, whereas 4,4-dimethyl cyclohexenone and isophorone are unreactive.
9. **a.** $Me_3TlBuLi$: prepared by adding sequentially 1 eq of MeLi and 1 eq of BuLi to a suspension of Me_2TlCl in ether. **b.** Me_2TlBu_2Li: formed by adding 2 eqs of BuLi to a suspension of Me_2TlCl in ether.
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14. For a recent report on the preparation and some reactions of indium ate complexes, see: Araki, S.; Shimizu, T.; Jin, S.-J.; Butsugan, Y. *J. Chem. Soc. Chem. Commun.*, **1991**, 824.

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