Reaction of Electrophiles with 1,3-Bis(trimethylsiloxy)-1-methoxybuta-1,3-diene, a Dianion Equivalent of Methyl Acetoacetate†

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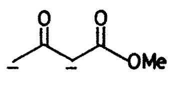
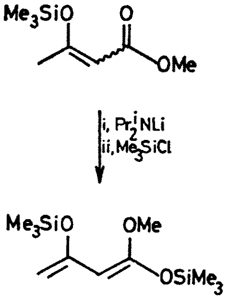
Summary The title compound reacts with a number of electrophiles with a different reactivity from that of the dianion of methyl acetoacetate.

ENOL silyl ethers[1] were first introduced into organic synthesis as precursors for specific enolate anions,[2] and subsequently have been used as such in numerous reactions with electrophiles.[1] Recently, it has been recognised that enol silyl ethers and enolates can have quite different reactivities and thus complement each other in their synthetic applications. A case in point is that whereas enolates can be alkylated by primary or secondary halides, enol silyl ethers are alkylated by tertiary halides.[3]

We feel that such differences in reactivity will be accentuated for enolate dianions and their enol silyl ethers. Since enolate dianions have recently enjoyed considerable attention, a systematic investigation in the chemistry of their silyl ethers may prove interesting as well. The dianion of methyl acetoacetate[4] (**1**) is particularly useful for the synthesis of natural products, because the acetoacetate unit is one of the fundamental building blocks in the biogenesis of natural products. Because of its dianion character, (**1**) is extremely reactive, and can be considered as a hard nucleophile. Typically, (**1**) reacts with αβ-unsaturated carbonyl compounds in a 1,2-addition fashion.[5]



(1)



(2)

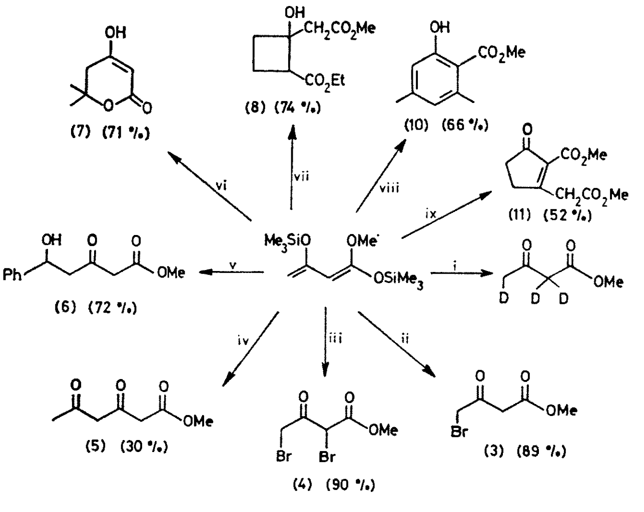
We have prepared 1,3-bis(trimethylsiloxy)-1-methoxybuta-1,3-diene[6] (**2**) by treating methyl 3-trimethylsiloxycrotonate with lithium di-isopropylamide in tetrahydrofuran containing tetramethylethylenediamine at −78 °C followed by quenching with trimethylchlorosilane. Judged from its n.m.r. spectrum, (**2**) exists entirely as one geometric isomer, tentatively assigned as the *E*-isomer.[7] The structure of (**2**) is confirmed by its ready hydrolysis to methyl acetoacetate. When the hydrolysis was conducted in D_2O, methyl 2,2,4-trideuterioacetoacetate was obtained.

The difference in the chemical reactivity of (**1**) and (**2**) can be demonstrated with bromine as the electrophile. Because of its reactivity, reaction of (**1**) with bromine can give a number of products. On the other hand, (**2**) is very selective, reacting with 1 mol of bromine to give (**3**), and with 2 mol of bromine to give (**4**) in good yield. Despite their rather simple structures, neither compound (**4**) nor its parent acid have previously been prepared.

Reaction of (**2**) with acetyl chloride occurred readily to give a complicated mixture of *C*-acetylated compounds. When the reaction was conducted in ether at −78 °C, the poly-β-carbonyl compound[5] (**5**) was obtained as the only product but in low conversion.

With other less reactive carbon electrophiles, activation by titanium tetrachloride[8] is necessary for reaction to occur. For example, (**2**) reacted with benzaldehyde in the presence of titanium tetrachloride to give the adduct[5] (**6**) in good yield. Similarly, reaction of (**2**) with acetone and titanium tetrachloride gave the lactone (**7**) which exists as a mixture of keto–enol tautomers.

We have found that heating ethyl acrylate with the diene (**2**) leads to the product of Michael addition at the 4-position followed by cyclization. The yield of the product (**8**) was improved by performing the reaction at −78 °C in the presence of titanium tetrachloride.[9] The propensity of (**2**) to undergo Michael addition has been used to advantage in an interesting cycloaromatisation reaction. Condensation of (**2**) with 4-trimethylsiloxypent-3-en-2-one (**9**) in the presence of titanium tetrachloride gave the aromatic compound (**10**). This should be contrasted with the reaction of (**2**) and pentane-2,4-dione under identical conditions which gave only recovered starting materials.‡



Reagents: i, D_2O; ii, 1 mol Br_2; iii, 2 mol Br_2; iv, AcCl, ether, −78 °C; v, PhCHO, $TiCl_4$; vi, acetone, $TiCl_4$; vii, $CH_2{=}CHCO_2Et$, $TiCl_4$; viii, $MeC(OSiMe_3){=}CHCOMe$, $TiCl_4$; ix, 2 mol $TiCl_4$.

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† For Part 1 of the series Chemistry of Enol Silyl Ethers, see ref. 3a.

‡ Transfer of the trimethylsilyl group from (**2**) to pentane-2,4-dione may account for the lack of reaction.

In the absence of electrophiles, titanium tetrachloride caused (**2**) to undergo dimerisation[10] followed by cyclisation to give the interesting cyclopentenone compound (**11**) which can be converted into methyl *cis*-jasmonate.[11]

Experiments performed so far indicate therefore that (**2**) can complement (**1**) in reactions with electrophiles. Of particular interest is the use of (**2**) for the synthesis of the cyclopentenone (**11**) and the cycloaromatisation.

We thank the Natural Science and Engineering Research Council of Canada, and the Ministry of Education, Government of Quebec, for financial support.

(*Received*, *2nd April* 1979; *Com.* 350.)

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