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A NEW REARRANGEMENT REACTION OF 2-CHLORO-1-TRIMETHYLSILYL ALKOXIDE. PREPARATION OF β-HYDROXYALKYL- OR β-KETOALKYLTRIMETHYLSILANES

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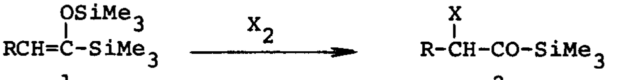
It has recently been reported that the reductice silylation reaction of carboxylic ester with metallic sodium--trimethylchlorosilane affords the corresponding 1,1-bis(trimethylsilyl)alkan-1-ol,[1] and its lithium alkoxide is easily converted into the trimethylsilyl enol ether of acylsilane 1 through oxidation reaction with benzophenone.[2] This paper describes a convenient preparative method of α-haloacylsilane 2 by the way of the silyl enol ether 1 and the reaction of α-chloro derivative with Grignard reagents, which provides an efficient method for the preparation of the compounds possessing title functional groups in regiospecific manner.

Silyl enol ethers of ketones are well known to be excellent precursors to the various α-functionalized ketones.[3] The silyl enol ether 1 is also found to undergo facile introduction of functional groups into α-position.[4] Thus, 1 is easily converted into the corresponding α-chloro- or α-bromoacylsilane 2[5] in high yield on treating with nearly equimolar amount of chlorine or bromine in carbon tetrachloride for short period.[6] Even if the starting silyl enol ether possesses another C=C bond, the latter remains unattacked with halogen under the reaction condition employed here.

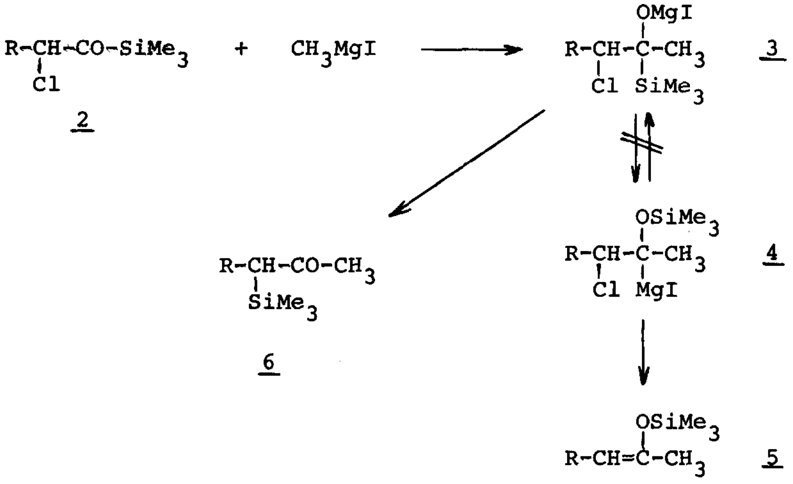


$$RCH=\overset{\overset{\displaystyle OSiMe_3}{|}}{C}-SiMe_3 \xrightarrow{X_2} R-\overset{\overset{\displaystyle X}{|}}{C}H-CO-SiMe_3$$

1 2

X = Cl, Br

In the next place, the reaction of the chlorinated one 2 (X = Cl) with Grignard reagents has been examined under the expectation that the adduct 3 initially formed would afford the corresponding trimethylsilyl enol ether of ketone 5 if equilibrium exists between 3 and 4 through silyl group rearrangement (Brook rearrangement[7]). However, on the contrary to expectation, β-ketoalkyltrimethylsilane 6 was obtained in an excellent yield when 2 was treated with equimolar amount of methylmagnesium iodide as shown in the following example.

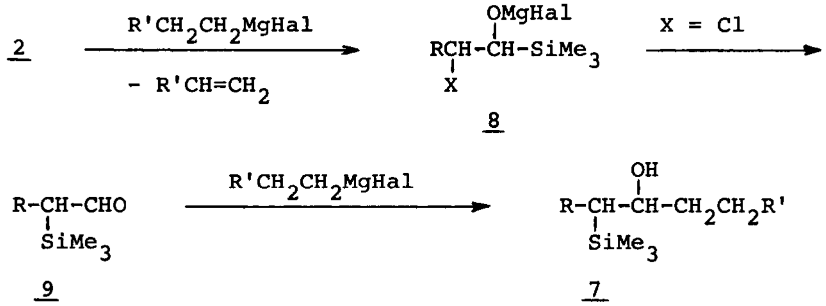


To THF (20 ml) solution of 2-chloro-3-phenylpropionyltrimethylsilane (4.80 g, 20 mmol) was added methylmagnesium iodide (21.8 ml of 0.95 molar ether solution) at -78°. After it was stirred for 30 min at that temperature, the reaction mixture was diluted with hexane (200 ml) and was washed with aq solution of satd NH_4Cl. Removal of the solvent followed by bulb to bulb distillation afforded 4-phenyl-3-trimethylsilyl-butan-2-one, 4.07 g (98%), BP_1: 115--120°.[8]

These results have suggested that silyl group transfer to the neighboring carbon atom takes place preferentially in the system of 2-chloro-1-trimethylsilyl alkoxide even under such a mild reaction condition. Intermediary formation of α,β-epoxysilane can be excluded because Mg^{2+} cation induced rearrangement of such material should afford another product resulting from α-cleavage of α,β-epoxysilane.[9] Thus, the reaction is considered to proceed through initial removal of chloride ion from the alkoxide 3, followed by rearrangement of trimethylsilyl group to the cationic site generated to afford 6. It is not conclusive yet whether both of these processes occur successively or in concerted manner, but two of them are expected to be favorable ones; the first stage may be facilitated by σ-π interaction with neighboring silyl group[10] and the second one may be accelerated with the aid of the oxyanionic character of O-Mg bond.

On contrary, when the reaction was attempted with the Grignard reagent possessing β-hydrogen, it resulted in the formation of β-hydroxyalkyltrimethylsilane 7, instead of β-ketoalkyltrimethylsilane. For example, the reaction of 2 (R = $C_6H_5CH_2$, X = Cl) with 1 eq of hexylmagnesium bromide afforded a mixture of 7 (R = $C_6H_5CH_2$, R' = C_4H_9, 39%) and 3-phenylpropanal (18%) along with the recovered starting material (17%), while similar treatment with 2 eq of the Grignard reagent led to the exclusive formation of 7 (96%).[11]

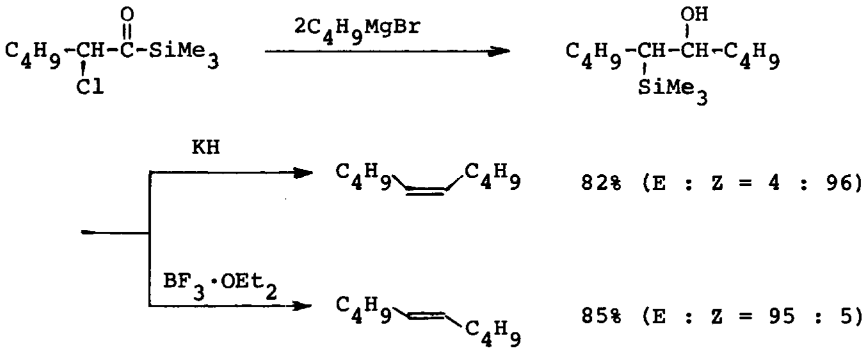
In connection with such a transformation, it has been reported by Brook et al[12] that, instead of addition reaction, reduction of acylsilane takes place preferentially to yield α-trimethylsilyl alkoxide 8 (X = H) when β-hydrogen is available in Grignard reagent. Thus, similar to the case with 3, the alkoxide 8 (X = Cl) initially formed would undergo the same type of transformation to yield α-trimethylsilyl aldehyde 9, which reacts further with Grignard reagent to give 7.



$$\underline{2} \xrightarrow[-\ R'CH=CH_2]{R'CH_2CH_2MgHal} \underset{\underline{8}}{RCH(X)\text{-}CH(OMgHal)\text{-}SiMe_3} \xrightarrow{X\ =\ Cl}$$

$$\underset{\underline{9}}{R\text{-}CH(SiMe_3)\text{-}CHO} \xrightarrow{R'CH_2CH_2MgHal} \underset{\underline{7}}{R\text{-}CH(SiMe_3)\text{-}CH(OH)\text{-}CH_2CH_2R'}$$

According to Cram's rule,[13,14] selective formation of erythro isomer was expected in the reaction of 9 with Grignard reagent since trimethylsilyl group behaves as much more bulky one than most of the alkyl groups. This assumption was verified as shown in the following example.[14] 2-Chlorohexanoyltrimethylsilane was treated with 2.2 eq of butylmagnesium bromide in THF at -78° for 30 min, and 7 ($R = C_4H_9$, $R' = C_2H_5$) was isolated in 85% yield. The β-hydroxyalkyltrimethylsilane thus obtained could be converted into E- and Z-5-decene selectively on treating with KH and $BF_3 \cdot OEt_2$, respectively, as shown in the following equation.



$$C_4H_9\text{-}CH(Cl)\text{-}C(=O)\text{-}SiMe_3 \xrightarrow{2C_4H_9MgBr} C_4H_9\text{-}CH(SiMe_3)\text{-}CH(OH)\text{-}C_4H_9$$

$$\xrightarrow{KH} C_4H_9CH{=}CHC_4H_9 \quad 82\%\ (E : Z = 4 : 96)$$

$$\xrightarrow{BF_3 \cdot OEt_2} C_4H_9CH{=}CHC_4H_9 \quad 85\%\ (E : Z = 95 : 5)$$

Table. Preparation of α-Haloacylsilane 2 and its Conversion into β-Ketoalkyltrimethylsilane 6 and β-Hydroxyalkyltrimethylsilane 7

R	Yield % 1 → 2(Cl)	1 → 2(Br)	2 → 6	2 → 7(R'=C_4H_9)
C_3H_7	83	81	91	90
C_5H_{11}	89	92	90	90
CH_2=CH$(CH_2)_6$	82	85	91	92
C_6H_5	97	87	98	96

References and Notes

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(3) For regiospecific halogenation, see; R. H. Reuss and A. Hassner, J. Org. Chem., **39**, 1785 (1974).

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