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# Cross-coupling of Alkyl Organomanganese Compounds with β-Chloroalkenyl Ketones

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*Alkyl organomanganese compounds RMnCl react with β-chloro-α,β-unsaturated ketones to give high yields of β-alkyl- or β,β-dialkyl-substituted α,β-unsaturated ketones.*

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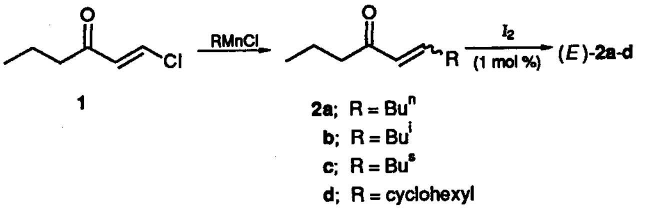
Organomanganese compounds such as RMnX, $R_2Mn$, $R_3MnLi$, or $R_3MnMgBr$ (R = alkenyl, alkyl, alkynyl, aryl; X = Cl, Br, I) are effectively the reactions acyldemetallation,[1] conjugate addition[2] and cross-coupling with alkenyl and allyl halides[3] to form a new carbon—carbon bond. To develop convenient synthetic methods for the preparation of α,β-unsaturated ketones, we studied the potential of β-halogen substituted alkenyl ketones to participate in cross-coupling with alkyl σ-complexes of divalent manganese. It is known from the literature[4] that mostly the products of 1,2-addition are formed in reactions of the β-halogen substituted alkenyl ketones with lithium and magnesium organic compounds. With organocuprate reagents, the halogen is smoothly replaced by an alkyl fragment only for cyclic β-chloro-α,β-unsaturated ketones.[5]

We have found that the manganese alkyl derivatives RMnCl ($R = Bu^n, Bu^i, Bu^s$, cyclohexyl) prepared *in situ* from $Li_2MnCl_4$ and RLi[1] react with *trans*-β-chlorovinyl propyl ketone **1** in tetrahydrofuran at – 78 °C for 2 h to lead to high yields of β-alkylsubstituted enones **2a–d** (Table 1).



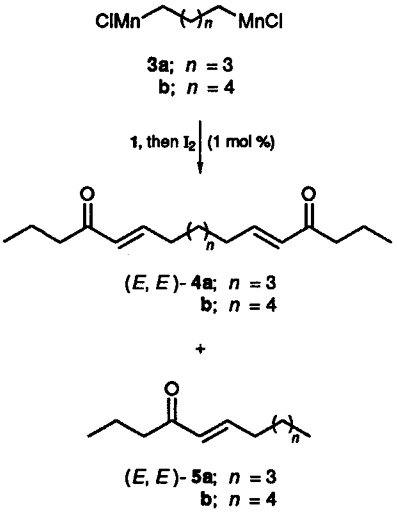
On the basis of TLC data, reactions of the chloride **1** and $Bu^nMnCl$ or $Bu^iMnCl$ result in the (*Z*)-isomers of the enones **2a, b**, which partially isomerized to the (*E*)-isomers during their isolation. The cross-coupling products are completely isomerized to the (*E*)-products in the presence of 1 mol% of $I_2$ in $Et_2O$ at 20 °C for 0.5 h. In contrast to $Bu^nMnCl$ and $Bu^iMnCl$, the derivatives $Bu^sMnCl$ and (cyclohexyl) MnCl give the ketones **2c, d** as a mixture of stereoisomers. Note our earlier observations of the changed double-bond geometry in the alkenyldemetallation of organomanganese compounds.[3b]

**Table 1** Reactions of organomanganese compounds with β-chloroalkenyl ketones

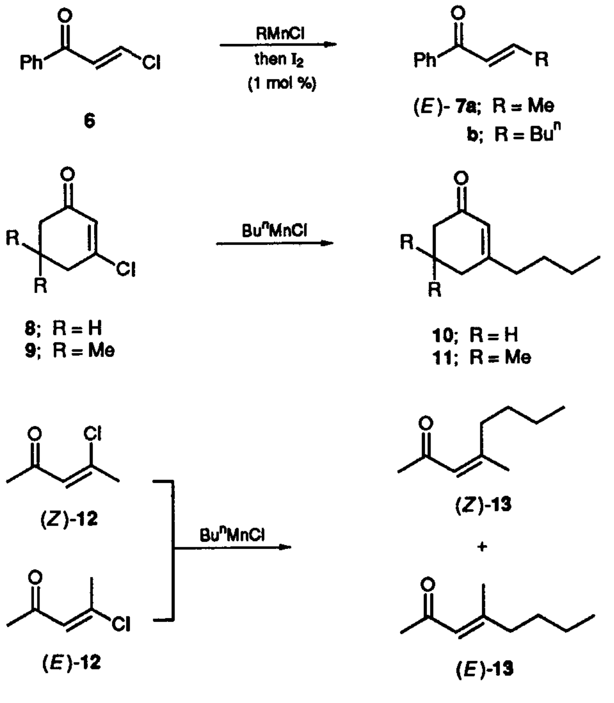
| Reagent | Substrate | Reagent to substrate ratio[a] | Product[b] | Yield (%)[c] |
|---|---|---|---|---|
| $Bu^nMnCl$ | **1** | 1.1:1 | (*E*)-**2a** | 85 |
| $Bu^iMnCl$ | **1** | 1.3:1 | (*E*)-**2b** | 95 |
| $Bu^sMnCl$ | **1** | 1.7:1 | (*E*)-**2c** | 83 |
| $C_6H_{11}MnCl$ | **1** | 1.5:1 | (*E*)-**2d** | 87 |
| **3a** | **1** | 0.75:1 | (*E,E*)-**4a** | 56 |
| | | | (*E*)-**5a** | 33 |
| **3b** | **1** | 0.75:1 | (*E,E*)-**4b** | 49 |
| | | | (*E*)-**5b** | 20 |
| MeMnCl | **6** | 1.1:1 | (*E*)-**7a** | 87 |
| $Bu^nMnCl$ | **6** | 1.3:1 | (*E*)-**7b** | 40[d] |
| $Bu^nMnCl$ | **8** | 1.7:1 | **10** | 72 |
| $Bu^nMnCl$ | **9** | 1.7:1 | **11** | 75 |
| $Bu^nMnCl$ | (*Z*)-**12** | 1.1:1 | **13** ($E:Z = 60:40$)[e] | 80 |
| $Bu^nMnCl$ | (*E*)-**12** | 1.1:1 | **13** ($E:Z = 40:60$)[e] | 98 |

[a] The ratios correspond to the minimum excess values at which the starting chloroketones are completely converted. [b] The product configurations were determined from $^1H$ and $^{13}C$ NMR spectral data; elemental analysis data were satisfactory for all compounds. [c] Yields of products isolated by column chromatography. [d] The reaction mixture was appreciably tarred. [e] According to the GLC data.

The reaction of the chloride **1** with the dimanganese derivatives **3a, b** results in a mixture of α,β-unsaturated diketones **4a, b** and monoketones **5a, b** in a *ca.* 2 : 1 ratio (Table 1).



In addition to the substrate **1**, we have used other β-chloroalkenyl ketones in the reactions with alkyl organomanganese compounds. Thus, reaction of MeMnCl or $Bu^nMnCl$ with *trans*-β-chlorovinyl phenyl ketone **6** gives the aromatic enones **7a, b**. The cross-coupling of $Bu^nMnCl$ with chlorocyclohexenones **8** and **9** leads to cyclic β-substituted enones **10** and **11**. The reaction of $Bu^nMnCl$ with either (*E*)- or (*Z*)-isomeric chloroketones **12**, each containing a trisubstituted double



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bond, results in a mixture of (*E*)- and (*Z*)-isomeric ketones **13** whose configuration is predominantly opposite to that of the initial chloride. Table 1 shows the product yields. It should be noted that the compounds (*Z*)-**13** and (*E*)-**13**, in contrast with (*Z*)-**2a–d** and (*Z*)-**7a–b**, are isomerized neither upon isolation, nor after being kept at 20 °C, nor under the GLC analysis conditions.

Therefore, the reactions of alkyl organomanganese compounds with β-chloroalkenyl ketones proceed under mild conditions to give high yields of β-alkyl- or β,β-dialkyl-substituted α,β-unsaturated ketones, providing a convenient synthetic method for the latter ketones.

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