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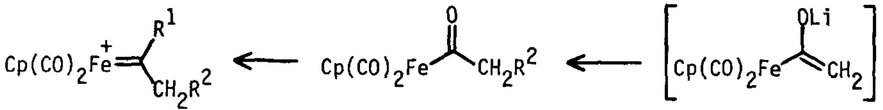
GENERATION AND REACTIONS OF THE LITHIUM ENOLATE OF THE IRON ACETYL COMPLEX $Cp(CO)_2FeCOCH_3$

Kerry Brinkman and Paul Helquist*
Department of Chemistry, University of Notre Dame
Notre Dame, Indiana 46556 USA

Summary: The title acetyl complex of the $Cp(CO)_2Fe$ system undergoes reaction with lithium hexamethyldisilazide to give the corresponding lithium enolate which reacts with a variety of electrophilic reagents.

The $Cp(CO)_2Fe$ system ($Cp = \eta^5\text{-}C_5H_5$) has proven to be one of the most widely useful groups in organometallic chemistry, especially as a result of the numerous synthetic organic applications that have been developed by Professor Rosenblum.[1] In our own laboratory, we have been studying the synthetic utility of alkylidene complexes of the general structure $[Cp(CO)_2Fe{=}CR^1R^2]^+$ (1).[2,3] Because the acyl complexes 2 readily serve as precursors of these carbene complexes,[3a,4,5] we considered the enolate 3 to be a potentially very useful reagent for incorporating iron alkylidene precursors into complex organic systems (eq 1). However, other workers have recently reported that this particular enolate cannot be generated as a useful intermediate because of competing pathways, at least when lithium diisopropylamide is used as the base.[6,7] Instead, enolate generation was limited to cases in which a phosphorus ligand was present in place of one of the carbonyl ligands on iron.[8] The resulting complexes, which are chiral at iron, are of course very useful in the study of asymmetric induction, but they do not provide access to the parent $Cp(CO)_2Fe$ system which is of much wider demonstrated utility than the phosphorus-substituted derivatives. In this communication, we are pleased to report a simple solution to this problem.

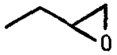


1 2 3

(1)

First of all, we are able to confirm that when the acetyl complex 4[4a,9] is allowed to react with lithium diisopropylamide followed by the addition of methyl iodide, acyl transfer to the Cp ligand and alkylation at iron result.[6,7] However, when lithium hexamethyldisilazide[10] is employed, the enolate 3 is formed as a reasonably stable intermediate (eq 2). It persists in solution up to ca. -50 °C, and it may be precipitated

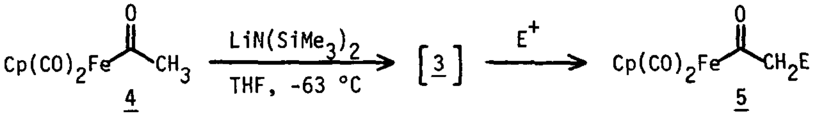
Table. Reaction of $Cp(CO)_2Fe\text{-}\overset{OLi}{\overset{|}{C}}{=}CH_2$ (3) with Electrophiles (eq 2)

Electrophile (E^+)[a]	Product (5)[b]	Yield (%)[c]
CH_3I	$FpCOCH_2CH_3$	84
$CH_3CH_2CH_2CH_2OTf$	$FpCOCH_2CH_2CH_2CH_2CH_3$	85
$(CH_3)_2CHOTf$	$FpCOCH_2CH(CH_3)_2$	60
$H_2C{=}CHCH_2Br$	$FpCOCH_2CH_2CH{=}CH_2$	54
$H_2C{=}C(CH_3)CH_2I$	$FpCOCH_2CH_2C(CH_3){=}CH_2$	92
$C_6H_5CH_2Br$	$FpCOCH_2CH_2C_6H_5$	56
$4\text{-}CH_3OC_6H_4CH_2I$	$FpCOCH_2CH_2C_6H_4\text{-}4\text{-}OCH_3$	96
	$FpCOCH_2CH_2CHOHCH_2CH_3$[d]	68
CH_3CH_2CHO	$FpCOCH_2CHOHCH_2CH_3$	62

[a] The molar ratios of electrophile:3 were 1.2:1.0. [b] $Fp = Cp(CO)_2Fe$. [c] All yields are for products that have been purified by silica gel chromatography. [d] One mol-equiv of $BF_3{\cdot}Et_2O$ was employed.

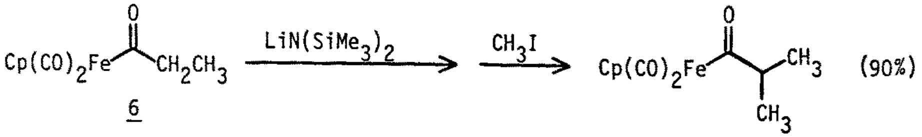
from THF solution by addition of ether, hexane, or other solvents of low polarity. Of greatest importance is its reactivity toward various electrophilic reagents (E^+ in eq 2). Of the reagents that we have investigated to date, good yields of products are obtained with reactive alkylating agents such as methyl, allylic, and benzylic halides and alkyl triflates,[11] with epoxides (in the presence of a Lewis acid[12]), and with aldehydes. Our results are summarized in the Table. All of these results were obtained with only THF as the solvent; the use of $(Me_2N)_3PO$ (HMPA) or TMEDA as a co-solvent leads to faster rates of reaction but to no improvements in the yields of the final products.

When less reactive alkylating agents (e.g. primary iodides and tosylates) are employed, decomposition of the enolate becomes competitive with the desired substitution reactions. Obtained as the final products in these cases are the compounds resulting from alkylation at the iron nucleus; we have not determined the fate of the acetyl ligand in these reactions, but we assume that it is lost via a ketene-forming pathway. The same behavior is seen when potassium hexamethyldisilazide is used as a base irregardless of the alkylating agents employed.



(2)

Of importance to synthetic applications that we are studying is the extension of these reactions to more highly substituted acyl complexes as starting materials. Very promising is the result obtained with the propionyl complex 6[4a] (eq 3; the base and alkylating agent could be present simultaneously in this case). However, we have not been able to effect alkylation of the isobutyryl complex to date.



(3)

In conclusion, our preliminary results are of major importance for the development of further synthetic applications of the Cp(CO)$_2$Fe system. We are currently employing the above reactions in the preparation of complex alkylidene derivatives.

The following is a general procedure: A Schlenk tube containing LiN(SiMe$_3$)$_2$ (0.263 g, 1.58 mmol), THF (3 mL), and a magnetic stirring bar was cooled in a -63 °C bath (dry ice/chloroform). Then Cp(CO)$_2$FeCOCH$_3$ (0.330 g, 1.50 mmol) in THF (1 mL) was added via a cannula over a 1-min period. An additional 1-mL portion of THF was used to rinse residual acetyl complex into the reaction mixture (final concentration ca. 0.3 M). The orange-red solution was stirred at -63 °C for 15 min and then cooled to -78 °C. The alkylating agent (1.80 mmol) was then added with a syringe. The reaction mixture was stirred at -63 °C for 3 h and then allowed to warm to -20 °C over a 0.5-h period. The reaction was then quenched by addition of saturated aqueous NH$_4$Cl solution (0.25 mL), and the mixture was concentrated in vacuo. The residue was washed through alumina (2 x 6-cm column) with CH$_2$Cl$_2$, concentrated in vacuo, and purified by radial chromatography (24 cm diam. x 4 mm thick silica gel plate).

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