

Note

Al₂O₃-mediated deacetylation of CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate

Michael S. Holden *, Brooke L. Bedell, Brent M. Snader, Vu P. Bui

Department of Chemistry, Dickinson College, PO Box 1773, Carlisle, PA 17013, USA

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Abstract

Passage of the title compound through a short column of Al₂O₃ induces deacetylation to form CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate. This compound is shown to react with base to generate the stabilized enolate, which is dideuterated or dimethylated upon quenching with excess D₂O or CH₃I. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

The nucleophilic aromatic substitution reaction involving cyclopentadienyliron (haloarene) salts is a well-known transformation in organometallic chemistry [1]. Although most of the work in this area has utilized heteroatom nucleophiles, there have also been examples of stabilized carbanions as nucleophiles. The first examples were reported by Moriarty and Gill [2]; recently Abd-El-Aziz and co-workers have expanded the range of leaving groups to include the nitro functionality [3–5].

A noteworthy result in Moriarty and Gill's work was the deacetylation process that occurred when 1-benzoylacetone was employed as the nucleophile. When the enolate of 1-benzoylacetone was treated with any of a number of CpFe(chloroarene) salts, the isolated product, after acidic workup, was not the expected dicarbonyl compound **1**, but rather the monocarbonyl

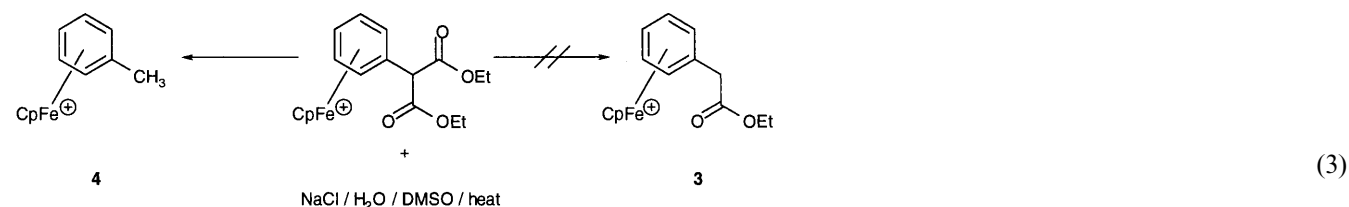
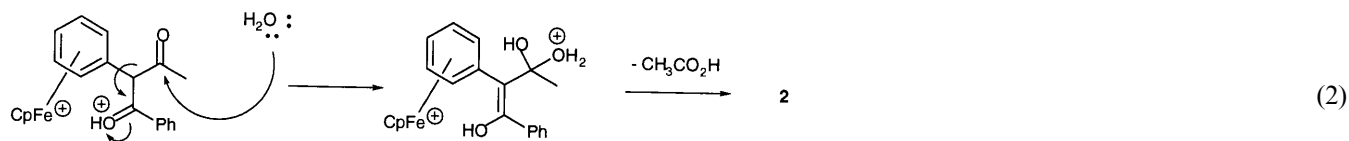
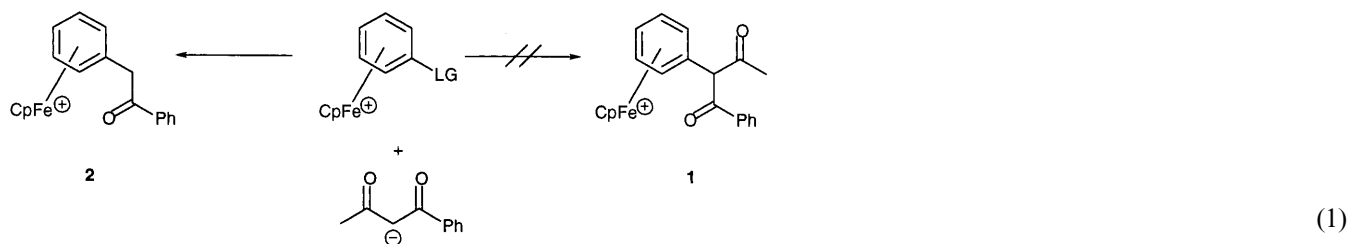
compound **2** (Eq. (1)). Moriarty and Gill postulated a reaction of a protonated form of expected product **2** with water, facilitated by the strongly electron-withdrawing nature of the CpFe(arene) moiety (Eq. (2)). We wish to report the results of our studies on the deacetylation of CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate, induced by passage through a column of deactivated Al₂O₃.

2. Results and discussion

As part of an ongoing effort, we required CpFe(arene) salts containing 1,3-dicarbonyl functionalities which could be decarboxylated under Krapcho conditions [6]. To this end, CpFe(2-phenyl diethylmalonate) was synthesized by the reaction of the enolate of diethylmalonate with CpFe(chlorobenzene). To our surprise, exposure of this compound to standard Krapcho conditions led not to the expected monocarboxylated iron salt **3**, but rather to the known [7] CpFe(toluene) complex **4** (Eq. (3)). Apparently, the electron-withdrawing nature of the CpFe(arene) permits a second decarboxylation to occur, which does not happen if the CpFe fragment is absent. In order to

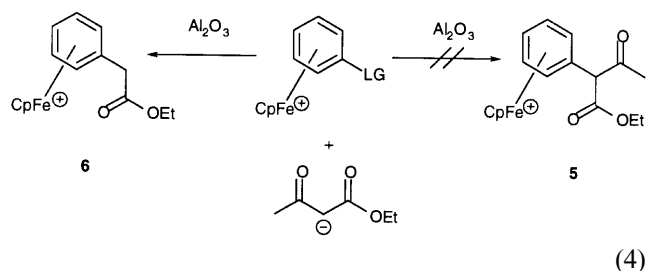
* Corresponding author. Tel.: +1-717-2451481; fax: +1-717-2451995.

E-mail address: holden@dickinson.edu (M.S. Holden).



investigate the parameters of this reaction, we chose to look at CpFe(arene) salts containing both an ester and a ketone functionality, to ascertain the relative ease of decarboxylation and decarbonylation.

CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate was synthesized by the reaction of the enolate of ethyl acetoacetate with CpFe(fluorobenzene). As part of the normal workup and purification, the crude product was passed through a short column of neutral alumina. Upon isolation, we were surprised to see that the product was not the expected CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate (**5**) but was instead the deacetylated compound CpFe(ethyl-2-phenylacetate) hexafluorophosphate (**6**) (Eq. (4)).



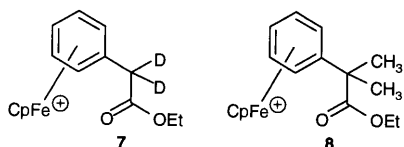
Analysis of the NMR data indicated that the crude product, before passage through the Al₂O₃, was the expected **5** but that it had been cleanly converted to **6** after treatment with Al₂O₃. Furthermore, solutions of **5** shaken with water for extended periods did not convert to **6**. Continuing investigation also showed that passage of a solution of **5** through a column of Al₂O₃ from a newly-opened jar led only to low yields of deacetylated **6**, with most of **5** passing through the column unchanged.

We prepared CpFe(ethyl-2-phenylacetoacetate) hexafluorophosphate and purified it by recrystallization. Samples of this iron compound were then dissolved in methylene chloride and eluted through a column of Al₂O₃. The collected samples were analyzed by ¹H-NMR to determine the amount of conversion from **5** to **6**. Preparation of neutral Al₂O₃ of Brockmann grades I–V [8] indicated that increased water content facilitated the deacetylation, as shown in Table 1. Basic Al₂O₃ also gave reasonable conversion, but acidic Al₂O₃ gave low conversion yields, accompanied by decomposition of the iron salts.

Table 1
Efficiency of deacetylation of (η⁵-cyclopentadienyl)iron(ethyl-2-phenylacetoacetate) hexafluorophosphate (**5**)

Activity grade of neutral Al ₂ O ₃	I	II	III	IV	V
Yield of 6 (%)	20	46	61	70	100

When **6** was treated with excess base, a benzylic proton was abstracted, as was indicated by the change in color of the solution from amber to the expected deep red. Quenching with excess D₂O or CH₃I led to the disubstituted products **7** and **8**, as the benzylic protons disappeared from the ¹H-NMR, being replaced in the case of **8** by a singlet representative of the two added methyl groups. Attempts to achieve monoalkylation have been unsuccessful, with stoichiometric additions of base and CH₃I leading to mixtures of unchanged **6** and mono and dialkylated products.



3. Conclusion

We have demonstrated a unique method for the deacetylation of the title compound and for the double decarboxylation of CpFe(2-phenyl diethylmalonate). Efforts are under way to improve the deacetylation process and to find a method of monoalkylation of the deacetylated adduct **6**. Work is also being carried out in an effort to use the double decarboxylation as a method for formal alkylation of CpFe(haloarene) compounds.

4. Experimental

4.1. (η^5 -Cyclopentadienyl)iron(toluene) hexafluorophosphate (**4**)

(η^5 -Cyclopentadienyl)iron(2-phenyl-diethylmalonate) hexafluorophosphate [**2**] (0.645 g, 1.29 mmol), NaCl (0.081 g, 1.39 mmol), water (0.070 ml) and dimethylsulfoxide (2.0 ml) were combined in a 25-ml RB flask equipped with a magnetic stir bar and reflux condenser with stopcock. The system was evacuated and placed under a balloon pressure of Ar, then heated at 160°C for 5 h. After cooling to r.t., the mixture was partitioned between 25 ml water and 25 ml methylene chloride. The organic layer was separated, dried (MgSO₄), filtered, and the solvent removed in vacuo. The resultant semi-solid was redissolved in ca. 1 ml methylene chloride, then added dropwise to 30 ml diethyl ether. The precipitated yellow solid was identical to the known [**7**] (η^5 -cyclopentadienyl)iron(toluene) hexafluorophosphate.

4.2. (η^5 -Cyclopentadienyl)iron(ethyl-2-phenylacetate) hexafluorophosphate (**5**)

(η^5 -Cyclopentadienyl)iron(fluorobenzene) hexafluorophosphate [**9**] (1.962 g, 5.419 mmol), ethyl acetoacetate (0.725 ml, 5.90 mmol), potassium carbonate (1.873 g, 13.55 mmol) and acetone (25 ml) were combined in a 100-ml RB flask equipped with a magnetic stir bar and stopcock. The system was evacuated and placed under a balloon pressure of Ar, then stirred for 18 h at r.t. The reaction mixture was filtered into a beaker containing 25 ml of 10% HCl. The acetone was removed by rotary evaporation and the aqueous solution was added to 250 ml water containing ammonium hexafluorophosphate (0.883 g, 5.42 mmol). The resultant yellow powder (1.33 g, 52%) was identical to the material obtained by the method of Moriarty and Gill [**2**].

4.3. (η^5 -Cyclopentadienyl)iron(ethyl-2-phenylacetate) hexafluorophosphate (**6**)

A pipette was packed with ca. 1.5 in. of neutral Al₂O₃ of the desired Brockmann activity. Compound **5** (0.300 g, 0.64 mmol) was dissolved in a minimum of methylene chloride and eluted through the column using acetone as the eluting solvent. The collected yellow fraction was concentrated in vacuo and the amount of conversion was determined by ¹H NMR analysis. For **6**, ¹H-NMR (CD₃COCD₃, 300 MHz): δ 6.43–6.54 (*m*, 5H, ArH), 5.24 (*s*, 5H, CpH), 4.18 (*q*, 2H, *J* = 7.0 Hz, OCH₂CH₃), 4.04 (*s*, 2H, ArCH₂), 1.24 (*t*, 3H, *J* = 7.0 Hz, OCH₂CH₃). ¹³C-NMR (CD₃COCD₃, 75 MHz): δ 168.36 (CO), 99.19, 88.40, 87.16, 86.55 (complexed aromatic), 76.48 (Cp), 60.25 (ArCH₂), 38.27 (OCH₂CH₃), 15.59 (OCH₂CH₃).

4.4. (η^5 -Cyclopentadienyl)iron(ethyl-2,2-dideuterio-2-phenylacetate) hexafluorophosphate (**7**)

(η^5 -Cyclopentadienyl)iron(ethyl-2-phenylacetate) hexafluorophosphate (**6**, 0.028 g, 0.065 mmol), potassium carbonate (0.138 g, 1.0 mmol), D₂O (0.5 ml) and acetone (5 ml) were placed into a 25-ml RB flask equipped with magnetic stir bar and stopcock. The system was evacuated and placed under balloon pressure of Ar, then wrapped with Al foil and stirred overnight. The system was concentrated in vacuo to remove the acetone and the remaining mixture was partitioned between water and methylene chloride. The organic layer was dried (MgSO₄), filtered and the solvent removed in vacuo to yield **7** as a yellow solid (0.021 g, 75%). ¹H-NMR (CD₃COCD₃, 300 MHz) δ 6.45–6.57 (*m*, 5H, ArH), 5.24 (*s*, 5H, CpH), 4.28 (*q*, 2H, *J* = 7.0 Hz, OCH₂CH₃), 1.30 (*t*, 3H, *J* = 7.0 Hz, OCH₂CH₃).

4.5. (η^5 -Cyclopentadienyl)iron(ethyl-2,2-dimethyl-2-phenylacetate) hexafluorophosphate (**8**)

(η^5 -Cyclopentadienyl)iron(ethyl-2-phenylacetate) hexafluorophosphate (**6**, 0.102 g, 0.237 mmol) and potassium *t*-butoxide (0.053 g, 0.474 mmol), were placed into a 25-ml RB flask equipped with magnetic stirrer bar, sidearm and stopcock. The system was evacuated and placed under balloon pressure of Ar, then tetrahydrofuran (12 ml) and methyl iodide (146 μ l, 2.37 mmol) were added via syringe. The system was wrapped with Al foil and the solution stirred overnight. The solution was partitioned between water and methylene chloride. The organic layer was dried (MgSO_4), filtered and the solvent removed in vacuo to yield **8** as a yellow solid (0.035 g, 32%). $^1\text{H-NMR}$ (CD_3COCD_3 , 300 MHz) δ 6.42–6.57 (*m*, 5H, ArH), 5.24 (*s*, 5H, CpH), 4.28 (*q*, 2H, $J = 7.0$

Hz, OCH_2CH_3), 1.77 (*s*, 6H, $\text{ArC}(\text{CH}_3)_2$), 1.30 (*t*, 3H, $J = 7.0$ Hz, OCH_2CH_3).

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