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Preliminary communication

Phenyl directing groups in the demethoxylation route to tricarbonyl(η^5-cyclohexadienyl)iron(1 +) complexes

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Abstract

Acid catalysed demethoxylation of tricarbonyl(η^4-2-methoxy-6-phenyl-1,3-cyclohexadiene)iron(0) leads to the exclusive formation of a 3-phenyl salt, rather than the product of minimum rearrangement, a 1-phenyl salt. With an additional 2-methyl substituent present, the competing directing influence is overcome by the phenyl group. The importance of the phenyl substituent in promoting regioselectivity is demonstrated by the demethoxylation of a 2,5-dimethyl-3-methoxy substituted complex, which led to a mixture of products.

Tricarbonyl(η^5-cyclohexadienyl)iron(1 +) cations bearing the elaborate substitution patterns often present upon 6-membered rings in natural products, would be valuable as electrophilic intermediates in organic synthesis [1]. A lack of regiocontrolled preparative routes to such dienyl systems is currently limiting their application. To increase the range of substituents that can be introduced, we have been examining new control effects in acid catalysed demethoxylation reactions of methoxydiene complexes [2].

In this paper, we describe the effect of phenyl substitution on the course of the demethoxylation process. Reactions of this type proceed via η^3-allyl intermediates, and can involve quite extensive rearrangement of the position of binding of the iron. Demethoxylation has been used extensively for the preparation of alkyl substituted cyclohexadienyl cations [3], and we have successfully employed this reaction to form 2-aryl substituted cyclohexadienyl complexes [4], a process in which no regiocontrol issues arise because of the 1,4 relationship between the aryl and OMe substituents.

In explorations of regiocontrol, we have now examined the demethoxylation of the 3-methoxy-5-phenyl complex **2a**, which was prepared in 88% yield from the 3-methoxy substituted dienyl complex **1a**, by alkylation with diphenylzinc. This

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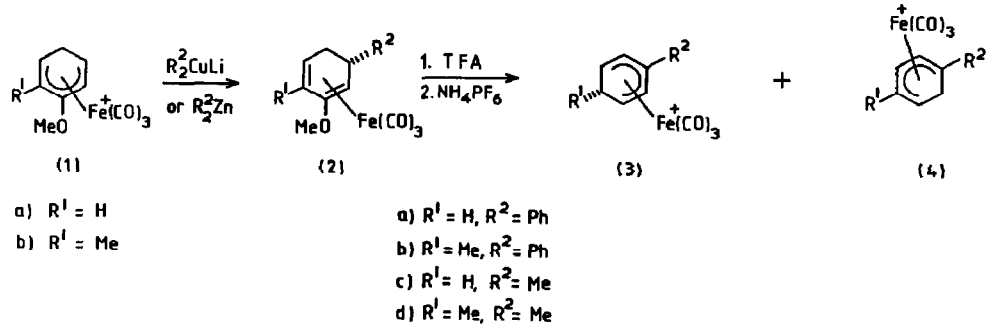
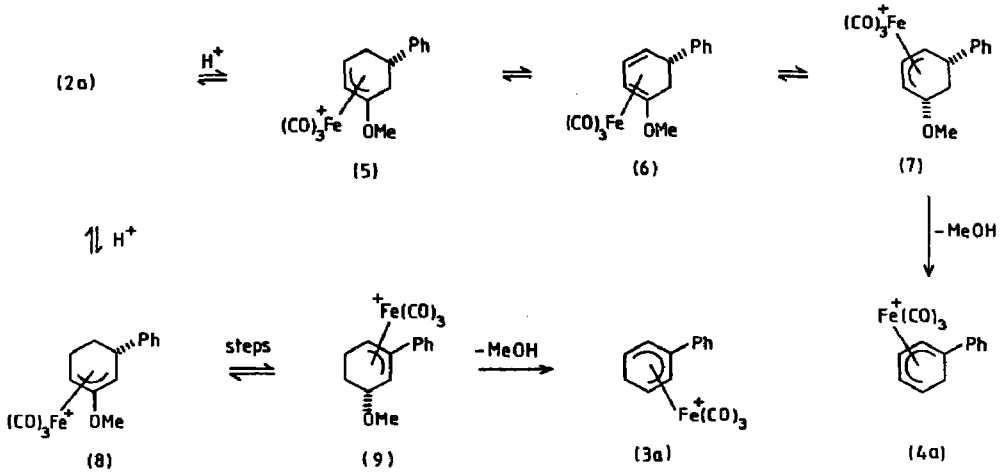


Scheme 1

methoxydiene complex could form either 1- or 3-substituted cyclohexadienyl products, depending on the direction of migration of the diene complex (Scheme 1, $R^1 = H$). The demethoxylation step was performed with TFA at 0 °C. The salt **3a**, precipitated by addition of NH_4PF_6, was easily identified as the 3-phenyl isomer from the simple NMR spectrum expected for a symmetrical product. The known [5] regioisomer **4a** was not detected.

The formation of **3a** can be accounted for in terms of the mechanism depicted in Scheme 2, which shows a sequence of isomerisation steps. The reaction sequence is consistent with deuterium labelling studies reported by Birch et al. [6] for loss of OMe from other methoxydiene complexes. The most direct route for demethoxylation of **2a**, the interconversion of **5**, **6**, and **7** by a series of protonation and deprotonation steps, does not lead to the production of dienyl cations under the conditions examined. Instead, the reaction is dominated by the phenyl substituent, which promotes the more extensive rearrangement path via **8** and ultimately **9**, leading to the production of **3a**.

The power of the directing influence of the phenyl substituent was tested by the preparation of **2b**, in which a 2-methyl substituent is placed next to the OMe group. An earlier study has defined the control influence of a substituent at this position,



Scheme 2

which is expected to disfavour demethoxylation via an intermediate of type **9** [2], and so should inhibit the formation of **3b**. Thus in **2b**, the directing influences of the methyl and phenyl substituents are placed in competition. The complex **2b** was produced in 71% yield, by alkylation of the known [7] dienyl salt **1b**, followed by separation of the regioisomeric products by chromatography. When reaction with TFA was examined under the conditions used to form **3a**, only the 6-*exo*-methyl product **3b** was observed, indicating that the phenyl group had completely overcome the control effect of the methyl substituent, and had again dominated the course of the reaction.

Two further demethoxylation reactions of methyl substituted complexes have been examined to provide a guide to the relative potency of each control effect. Demethoxylation of **2c**, prepared in 79% yield from **1a**, gave a single product **3c**, but **2d** (51% yield from **1b**) afforded a 7 : 3 mixture of cations **3d** and **4d**, the C-5 Me group being unable, in this case, to dominate the course of the reaction.

It is possible to account for the selectivity of these demethoxylation reactions by proposing that the preferred route retains the greatest number of substituents on the allyl intermediates. This effect may arise from the ability of substituents to stabilise positive charge in the allyl complexes. Our results demonstrate that 5-phenyl substituents are more powerful control groups than 5-methyl substituents, a property that reflects the greater stability of phenyl substituted cationic centres. While phenyl substituents always dominate the course of demethoxylation, alkyl substituents are effective only when unopposed by contrary directing influences. Since both alkyl and aryl groups are conveniently introduced by the alkylation of methoxy substituted dienyl cations, these methods provide a versatile approach for the controlled elaboration of cyclohexadienyl cations through a sequence of η^4 and η^5 complexes.

The observations reported here define new regiocontrol effects in the preparation of tricarbonyl(η^5-cyclohexadienyl)iron(1 +) salts of types that are now finding extensive application in organic synthesis. Prescribing the direction of isomerisation of the diene unit during the demethoxylation of chiral cyclohexadiene complexes is of particular importance, since racemisation of resolved [8*] organometallic centres must be avoided in demethoxylation steps if the value of the planar chirality of such materials in the control [1] of enantioselective organic synthesis is to be retained.

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