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Reaction of Cationic 1-Substituted (η^5-4-Methoxycyclohexadienyl)(Tricarbonyl)Iron Complexes with Anilines : A Revised Mechanism

Catherine Guillou*[a], Fabrice Bintein, Jean-Philippe Biron and Claude Thal

Institut de Chimie des Substances Naturelles, C.N.R.S., 91198 Gif-sur-Yvette Cedex (France)

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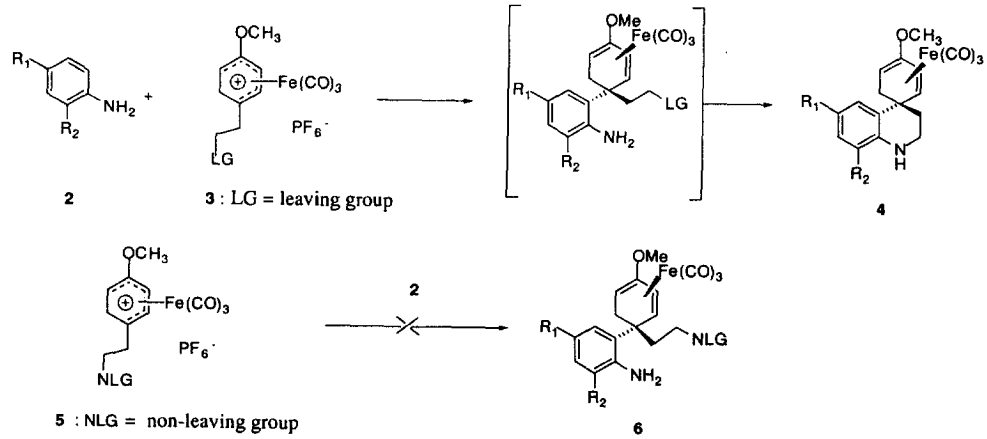
ABSTRACT : Reaction of *p*-anisidine **13** or *p*-bromo orthoanisidine **14** with the new bi-deuterated dienyl complex **12** bearing a leaving group on its side chain affords the mono-deuterated **18a**, **19a** and the non-deuterated **18b** and **19b** spiro[1,2,3,4-tetrahydroquinoline-4,1'-cyclohexane] derivatives. The formation of these products is not the result of a nucleophilic substitution of the leaving group present on cation **12**. The vinylogous dienyl π-complex **7** was proposed as the reaction intermediate.

The reaction of anilines with tricarbonyl iron-complexed cyclohexadienyl cations (e.g. **3**) has been largely studied and provides an interesting synthetic method to access biologically active carbazole alkaloids[1] and 3-azaspiro[5,5]undecanes **4**.[2] It has been proposed that the first step of the reaction of anilines **2** with 1-substituted (η^5-4-methoxycyclohexadienyl)(tricarbonyl)iron complexes **3** which possess a side chain bearing a leaving group is an electrophilic substitution of the aromatic ring of the aniline and that subsequent *in situ* nucleophilic substitution of the leaving group affords the spiro derivative **4** (scheme 1).[2] In a project aimed at the synthesis of natural products we planned to synthesize complexes **6** as useful synthetic intermediates. The complexes **6** could ideally be synthesized by reaction of aniline **2** with cationic iron complexes **5** devoid of a leaving group on their side chain in order to avoid the spirocyclization reaction (scheme 1).



Scheme 1

[a] E-mail : Guillou@icsn.cnrs-gif.fr

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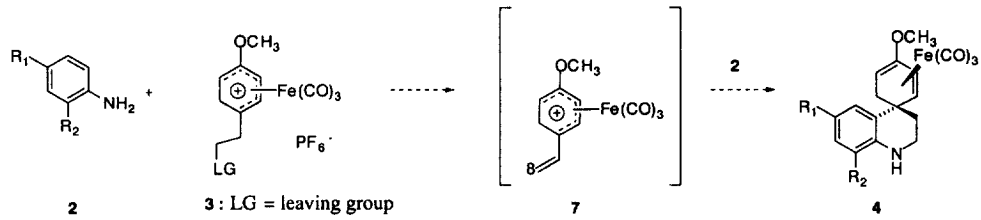
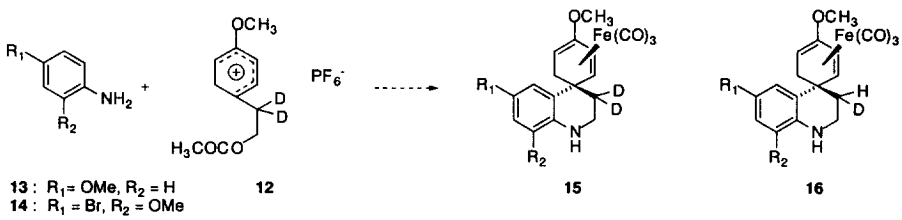
Contrary to expectation, anilines did not react with cations **5**. These results thus led us to reinvestigate the reaction of anilines **2** with cations **3**. As an alternative mechanism, we supposed that the first step of this reaction is an elimination of the leaving group in order to form *in situ* the vinylogous cation **7** which then reacts with aniline to form the spiro[1,2,3,4-tetrahydroquinoline-4,1'-cyclohexane] **4** (scheme 2). The vinylogous cation **7** has previously been synthesized and reacted with soft nucleophiles at carbon C-8.[3]



Scheme 2

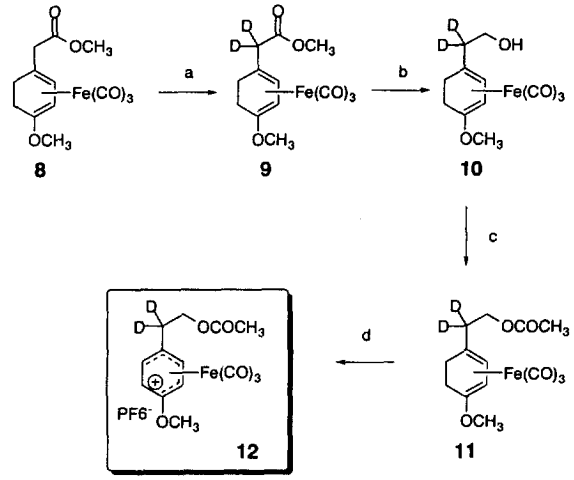
In order to elucidate the mechanism of this reaction, we now report the synthesis and the reaction of bi-deuterated complex **12** with *p*-anisidine **13** or with *p*-bromo orthoanisidine **14**. If the formation of compound **4** proceeds *via* an SN_2 displacement of the leaving group (i.e. *via* the mechanism of scheme 1), the bi-deuterated 3-azaspiro[5,5]undecane derivative **15** should be obtained (scheme 3). If the reaction proceeds *via* a vinylogous cation (i.e. *via* the mechanism of scheme 2), then a mono-deuterated product **16** should be obtained.



Scheme 3

The new cation **12** labeled with two deuterium atoms was synthesized by reaction of the ester complex **8** with a freshly prepared sodium methylate solution in methanol-*d* at room temperature in quantitative yield (scheme 4). NMR and the mass spectral analysis revealed formation of greater than 99% of the bi-deuterated product **9**. Subsequent reduction of the bi-deuterated ester **9** with lithium borohydride in ethylene glycol dimethyl ether afforded the corresponding alcohol **10**. Reaction of **10** with acetyl chloride led to the

complex **11** in good yield which then underwent hydride abstraction on treatment with triphenylcarbenium hexafluorophosphate in dichloromethane to give the bi-deuterated cation **12** .



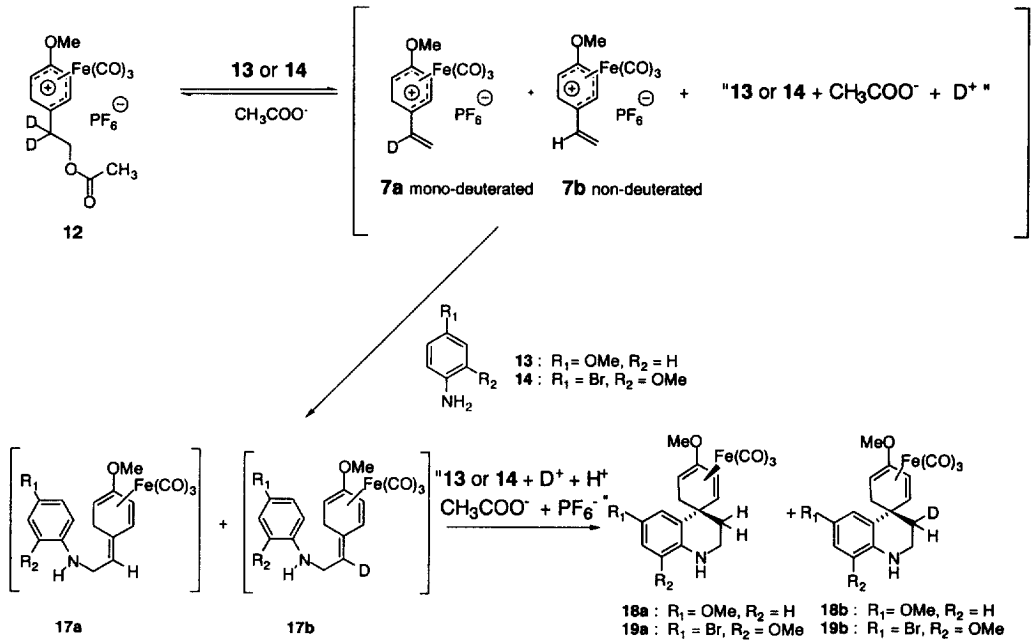
(a) : CH_3ONa, CH_3OD, 25°C, 4h (99%). (b) $LiBH_4$, DME, 25°C, 27h (80%). (c) : CH_3COCl, CH_2Cl_2, pyridine, 25°C, 2.5h (90%). (d) : $Ph_3C^+PF_6^-$, CH_2Cl_2, reflux, 0.5h (85%).

Scheme 4

Reaction of cation **12** with *p*-anisidine **13** (CH_3CN/ 25°C/ 30 min) or with *p*-bromo orthoanisidine **14** (CH_3CN/ 25°C/ 24 h) afforded in 55% and 42% yield respectively the 3-azaspiro[5,5]undecane derivatives as a 50/50 mixture of the non-deuterated compounds **18a, 19a** and mono-deuterated compounds **18b, 19b** (scheme 5). The formation of these products is thus not the result of a nucleophilic substitution of the acetate leaving group present on cation **12** by the amine.

The following mechanism is proposed to rationalize these results (scheme 5). Elimination of the leaving group of **12** leads to the vinylogous mono-deuterated cation **7a** and non-deuterated cation **7b**. The formation of the non-deuterated cation **7b** can be explained by successive addition and elimination reactions of the nucleophiles present in the reaction mixture with the mono-deuterated cation **7a** and concomitant protonation . The cations **7a-b** react at carbon C-8 with anilines **13** and **14** to form *in situ* the complexes **17a-b**. Subsequent cyclization of **17a -b** affords compounds **18a-b** and **19a-b**.

This is corroborated by our observation that the reaction of isolated non-deuterated vinylogous cation **7**[4] with *p*-anisidine **13** afforded **18a.**



Scheme 5

In conclusion, the present deuterium- labeling results establish that anilines do not react with the dienyl iron complex **12** *via* an electrophilic substitution of the aromatic ring of the aniline and subsequent nucleophilic substitution of the leaving group as previously believed. Instead, the vinylogous dienyl-π complex **7** is proposed as the *in situ* intermediate of this reaction.

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3) a) Stephenson, G. R.; Voyle, M.; Williams, S. *Tetrahedron Lett.* **1990**, *28*, 3979-3982. b) Hudson, R. D. A.; Osborne, S. A.; Roberts, E.; Stephenson, G. R. *Tetrahedron Lett.* **1996**, *37*, 9009-9012.
4) A new preparation of the vinylogous cation **7** will be soon reported.