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THE SYNTHETIC USE OF α-FERROCENYLCARBENIUM TETRAFLUOROBORATES

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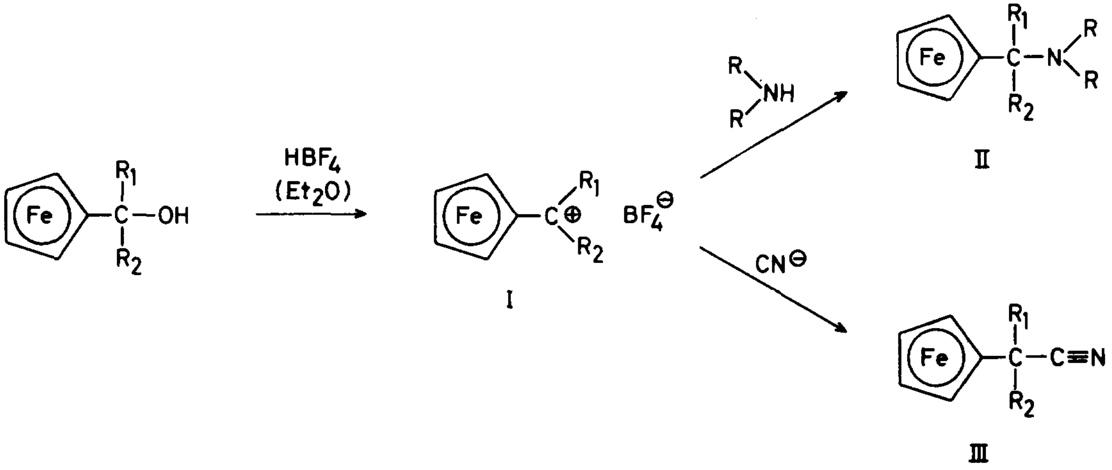
The remarkable stability of α-ferrocenylcarbenium ions is evident from solvolysis experiments[1] as well as generation from carbinol precursors in acid media and direct spectroscopic observation.[2] The latter has also permitted determination of pK_R-values for the carbinol-carbenium ion equilibria.[3] In some cases salts containing the carbenium ion have been isolated.[4] Despite the great current interest in this field, however, the synthetic usefulness and importance of such salts do not seem to have been recognized.

This communication describes a simple route for the preparation of some different α-ferrocenylcarbenium tetrafluoroborates (I) and their ready conversion to various amines (II) or nitriles (III) in a rapid, convenient, high-yield operation.

Of the methods available for the generation of carbenium ions, such as protonation of an olefinic bond,[5] hydride abstraction from a saturated carbon atom[6] or protonation and water removal from a carbinol function,[2] the last method is most attractive from a synthetic viewpoint, because α-ferrocenylcarbinols are easily obtained from ferrocene.[7] Although many nucleophilic substitution reactions can be carried out in an acid solution of the carbinol,[8] this method fails in those cases where the nucleophile (e.g. an amine or a cyanide ion) is made ineffective by protonation.

In view of the importance of chiral amines of the α-ferrocenylalkylamine type (II) in connection with Ugi's 4CC-method for peptide synthesis,[9] methods for their preparation have been the subject of many investigations.[10] A compound of particular interest is N,N-dimethyl-1-ferrocenylethylamine (IId)[10f] because of its easy optical resolution into enantiomers.[11]

Experiments carried out in this laboratory have shown that the difficulties earlier associated with the amine syntheses are overcome if a route via the isolation of the salts I is used. The method appears to have a quite general applicability and should therefore not only be restricted to the conversion I→II or I→III. Although not yet fully explored, the reaction of I with a variety of nucleophilic reagents opens new synthetic pathways of great potential interest.



R_1	R_2	Salt I	R	Amine II	Nitrile III	Yields (%) from carbinol
C_6H_5	C_6H_5	Ia	H	IIa		95
			CH_3	IIb		98
			-		IIIa	98
C_6H_5	H	Ib	CH_3	IIc		95
			-		IIIb	90
CH_3	H	Ic	CH_3	IId		94

The amines and nitriles prepared in this way were completely characterized by their PMR-spectra and by comparison with known physical data and their purities ascertained by TLC.

Method. To a solution of the carbinol (2 mmole) in 25 ml of anhydrous diethyl ether is first added 0.25 ml of acetic anhydride, followed by 1.5-2 ml of commercial (Schuchardt) 54 % fluoboric acid in diethyl ether at room temperature. A dark, crystalline precipitate of I is rapidly formed. This is immediately filtered off by suction and carefully washed with anhydrous diethyl ether. Direct use is recommended and prolonged exposure of the salt to air should be avoided; this is particularly important when working with Ic. The salts I are almost insoluble in diethyl ether and this method of preparation gives essentially quantitative yields. Because of their great solubility in dichloromethane, this solvent was chosen for their conversion to II and III.

I→II. A sufficient excess of dry dimethylamine or ammonia is passed into 50 ml of dichloromethane. I is then added under efficient stirring at room temperature. The dark colour (violet to blue-black) obtained on dissolution of I immediately changes into yellow and the reaction is complete within a few seconds. Filtration, evaporation of the solvent, addition of dilute alkali and extraction with ether, drying and evaporation, gives quite pure amine.

IIb was also prepared in an alternative way: A solution of the salt Ia in anhydrous dichloromethane was shaken in a separatory funnel with aqueous (40 %) dimethylamine. Separation of the organic phase, drying and evaporation gave IIb in an almost quantitative yield.

I→III. The salt I, dissolved in dry dichloromethane, was shaken with a water-solution of sodium cyanide. The organic phase was separated, dried and evaporated.

Further exploration of this method, especially the preparation and use of optically active[12] α-ferrocenylcarbenium tetrafluoroborates, is now in progress in this laboratory.

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