

Methylation of Tricarbonylcyclohexadienyliron Salts with Lithium Dimethylcuprate

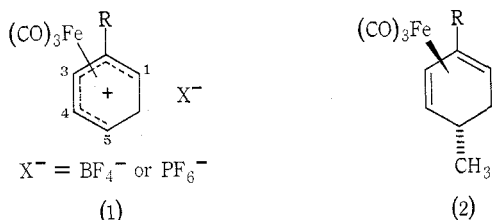
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Abstract

The reaction between various tricarbonylcyclohexadienyliron salts and lithium dimethylcuprate leads to stereospecific, regioselective methylation. Deuterium-labelled compounds are used to establish that alkylation occurs at the face of the dienyl system opposite to that occupied by $\text{Fe}(\text{CO})_3$.

We have recently reported¹ alkylations of tricarbonylcyclohexadienyliron complexes (1; $\text{R} = \text{H}, \text{CH}_3, \text{OCH}_3$) with organo-zinc and -cadmium reagents. This reaction is unsuccessful with dimethylzinc and dimethylcadmium, even under relatively forcing conditions (e.g. refluxing dibutyl ether). Although methylation of (1; $\text{R} = \text{H}$) has been achieved² with methylolithium, the yields were rather poor (39%). In the course of extending our studies on the chemistry of diene- $\text{Fe}(\text{CO})_3$ complexes, methylation products have been obtained in yields of up to 80% by use of lithium dimethylcuprate.



Reaction of tricarbonylcyclohexadienyliron tetrafluoroborate (1; $\text{R} = \text{H}$) with lithium dimethylcuprate produced tricarbonyl(5-methylcyclohexadiene)iron (2; $\text{R} = \text{H}$) in yields of 75–80% after purification by chromatography. That the methylation occurs on the face of the dienyl cation opposite to that occupied by $\text{Fe}(\text{CO})_3$ is shown by the following observations. The ^1H n.m.r. spectrum of (2; $\text{R} = \text{H}$) shows a two-proton multiplet at δ 2.1–2.3 and a one-proton doublet at δ 1.2, these being attributed to the H5 proton and to the protons of the C6 methylene group. The product formed by methylation of tricarbonyl(6-*exo*-deuteriocyclohexadienyl)iron tetrafluoroborate, containing 52% atom deuterium, shows the appropriate reduction in integrated intensity of the δ 1.2 signal, but no change in the lower field multiplet,

¹ Birch, A. J., and Pearson, A. J., *Tetrahedron Lett.*, 1975, 2379.

² Birch, A. J., Cross, P. E., Lewis, J., White, D. A., and Wild, S. B., *J. Chem. Soc. A*, 1968, 332.

indicating that the former is the chemical shift of the *exo*-H 6 proton. Methylation of tricarbonyl(1-deuterocyclohexadienyl)iron tetrafluoroborate (90% atom D) gave the compound resulting from addition to either terminus (deuterated and non-deuterated) and showing the methyl resonance at δ 0.95 as a combination of doublet (J 7 Hz) and singlet as expected. The integrated intensities at δ 2.3–2.1 and 3.15 (terminal protons of diene) both showed a reduction of approximately 0.4H, whilst the δ 1.2 signal showed no reduction. Thus, the signal at δ 2.3–2.1 is due to H 6*endo* and H 5. The coincidence of chemical shift for these two protons shows that H 5 must also be *endo* relative to the $\text{Fe}(\text{CO})_3$ group. Therefore, alkylation occurs on the *exo* face of the cation, a result which substantiates the same conclusion made for reactions with organocadmium reagents.¹

With the asymmetric complexes (1; $\text{R} = \text{CH}_3, \text{OCH}_3$) attack could occur at either terminus. The n.m.r. spectra of the products indicate exclusive methylation at C 5 with (1; $\text{R} = \text{OCH}_3$) and greater than 95% methylation at C 5 for (1; $\text{R} = \text{CH}_3$), so the reaction shows a high regioselectivity, probably due mainly to steric factors.

The reaction reported in the present communication is potentially more useful than our earlier alkylations, owing to the availability of functionalized organocuprates by literature procedures. Its scope is currently under investigation.

Experimental

N.m.r. spectra for solutions in deuteriochloroform were measured on a Jeol Minimar 100 MHz instrument; i.r. spectra (liquid film) were measured on a Perkin-Elmer 257 and mass spectra on A.E.I. MS9 spectrometers. All tricarbonylcyclohexadienyliron salts were prepared by published procedures.^{2,3}

Tricarbonyl(1-deuterocyclohexadienyl)iron Tetrafluoroborate

To a solution of tricarbonylcyclohexadienoneiron² (2 g) in ethanol (40 ml) at -10 to -15° was added sodium borodeuteride (0.46 g) in small portions with stirring over 30 min. The reaction mixture was stirred for a further 30 min, poured into water (100 ml) and extracted four times with light petroleum. The combined extracts were dried (MgSO_4), the solvent removed and the crude tricarbonyl(5-deutero-5-hydroxycyclohexa-1,3-diene)iron was dissolved in ether (10 ml) and filtered into a mixture of 40% aqueous fluoroboric acid (5 ml), acetone (10 ml) and ether (100 ml); a yellow precipitate of the tetrafluoroborate salt (500 mg) was immediately produced. After several hours the precipitate was removed at the pump, washed with ether and dried in air. The n.m.r. spectrum² showed c. 90% atom deuterium at C 1. The product from methylation (below) also indicated 90% atom deuterium in its mass spectrum.

Tricarbonyl(6-*exo*-deuterocyclohexadienyl)iron Tetrafluoroborate

An improved method for reduction of tricarbonylcyclohexadienyliron tetrafluoroborate was used. A suspension of this compound (2 g) in 1,2-dimethoxyethane (20 ml) was reduced with sodium borodeuteride (0.6 g) over a period of 30 min at 0°C . The mixture was poured into water (100 ml) and the product extracted with light petroleum, washed several times with water, dried (MgSO_4), solvent removed and the product chromatographed on silica (petrol eluent). N.m.r. and mass spectra of the product showed 66% monodeuteration in the methylene group of the tricarbonylcyclohexadienyliron. Hydride abstraction with triphenylmethyl tetrafluoroborate in the usual way² gave tricarbonyl(6-*exo*-deuterocyclohexadienyl)iron tetrafluoroborate containing 52% D_1 in the 6- CH_2 group. The n.m.r. spectrum in trifluoroacetic acid showed the appropriate reduction in integrated intensity of the δ 2.16 doublet, showing it to be the resonance of the *exo* proton, and the signal at δ 3.16 is assigned to the *endo* proton (assignments based on partial abstraction of deuteride from the *exo* position,^{2,4} the

³ Birch, A. J., and Haas, M. A., *J. Chem. Soc. C*, 1971, 2465.

⁴ Ireland, R. E., Brown, G. G., Jr, Stanford, R. H., Jr, and McKenzie, T. C., *J. Org. Chem.*, 1974, 39, 51.

results of which here also show a small isotope effect, k_H/k_D 3.7). The methylated product also showed 52% atom deuterium mass spectrum.

Methylation of Tricarbonylcyclohexadienyliron Salts

To a stirred suspension of cuprous iodide (380 mg) in dry ether (15 ml) at 0°C under a nitrogen atmosphere was added methylolithium (1.8 M in ether, Alpha Products) dropwise by typical syringe techniques until the first formed yellow precipitate of methyl copper just dissolved. The solution was stirred for a further 5–10 min, and the tricarbonylcyclohexadienyliron salt (200 mg) was quickly added. Rapid reaction occurred and the product was immediately poured into hydrochloric acid (5%, 30 ml), filtered and the ether layer removed, washed with water and dried (K_2CO_3 , Na_2SO_4). After removal of solvent under reduced pressure, the product was chromatographed on silica (petrol) to give the major product as a fast-running yellow band. Removal of petrol furnished a yellow oil in each case.

Tricarbonylcyclohexadienyliron tetrafluoroborate (1; R = H) gave tricarbonyl(5-*exo*-methylcyclohexadiene)iron (2; R = H) (120–130 mg, 74–80%). δ 5.3, 2H, m, H 2, H 3; 3.08, 2H, m, H 1, H 4; 2.3–2.1, 2H, m, H 5 and H 6_{endo}; 1.18, 1H, m, H 6_{exo}; 0.92, 3H, d, J 7 Hz, CH_3 . ν_{max} 2060, 1970 $Fe(CO)_3$. M^+ 234.

Tricarbonyl(2-methylcyclohexadienyl)iron hexafluorophosphate (1; R = CH_3) gave tricarbonyl(2,5-dimethylcyclohexadiene)iron (2; R = CH_3) (78 mg, 60%). δ 5.20, 1H, d, J 6 Hz, H 3; 2.95, 2H, m, H 1, H 4; 2.10, 3H, s, 2- CH_3 ; 2.2–2.0, 2H, H 5 and 1 $\times$ H 6; 1.1, 1H, m, 1 $\times$ H 6; 0.90, 3H, d, J 7 Hz, 5- CH_3 . Methyl protons of tricarbonyl(1,6-dimethylcyclohexadiene)iron are visible as a small singlet ($\leq 5\%$) at δ 1.56.

Tricarbonyl(2-methoxycyclohexadienyl)iron tetrafluoroborate (1; R = OCH_3) gave tricarbonyl(2-methoxy-5-methylcyclohexadiene)iron (2; R = OCH_3) (75 mg, 50%). δ 5.15, 1H, dd, J 7 and 3 Hz, H 3; 3.73, 3H, s, CH_3O ; 3.34, 1H, m, H 1; 2.70, 1H, dd, J 7 and 3 Hz, H 4; 2.10, 2H, m, H 5 and 1 $\times$ H 6; 1.28, 1H, m, 1 $\times$ H 6; 0.96, 3H, d, J 7 Hz, CH_3 . (Assignment based on ref.⁴) ν_{max} 2065, 1970 $Fe(CO)_3$. M^+ 264.

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