General Synthesis of Optically Pure Chiral Iron Primary Alkyls *via* a Metal-activated Alkylation Reagent

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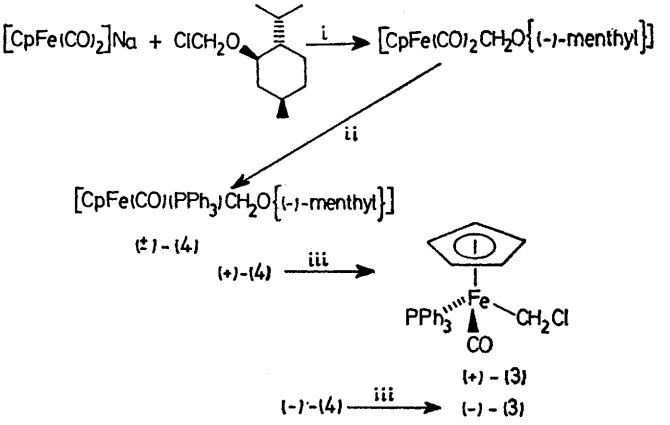
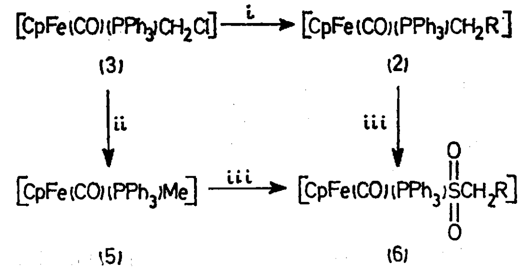
Summary Preparation of the optically pure alkylation reagent (**3**) and its reaction with Grignard and alkyllithium reagents provides a general route to iron alkyls whose enantiomeric purity may be shown by the n.m.r. spectra of their SO_2 insertion products.

THE work of Brunner and his co-workers[1] shows the potential of optical activity at metal centres to mechanistic studies in transition-metal chemistry. Although we have prepared an sp^3-carbon-bonded resolved metal complex, [CpFe(CO)(PPh$_3$)CH$_2$CO$_2${(−)-menthyl}] (**1**)[2] (Cp = η-C_5H_5) this compound is not readily converted stereospecifically into other chiral derivatives, and the presence of the β-acyl group may render its reactions atypical of an iron alkyl.



SCHEME 1; i, tetrahydrofuran, 25°; ii, *h*ν, PPh$_3$; iii, HCl, Et$_2$O.



SCHEME 2. i, RMgX or RLi, THF; ii, NaBH$_4$, dimethoxyethane; iii, SO_2, CH_2Cl_2.

We report, therefore, a new versatile synthesis of enantiomerically pure primary alkyliron complexes of the type [CpFe(CO)(PPh$_3$)CH$_2$R] (**2**).

The key intermediate is the resolved chloromethyl-iron derivative (**3**) which is prepared as shown in Scheme **1**.† Fractional crystallization of (±)-(**4**) from hexane and usually a single recrystallization of each diastereoisomer gives pure (+)- or (−)-(**4**) in up to 20% overall yields from [CpFe(CO)$_2$]$_2$.‡ The absolute configuration of (+)-(**4**) has been determined crystallographically, and is that shown for (+)-(**3**) in Scheme 1.[3] Hence, the absolute configuration of every compound reported here which is prepared from (**4**) (except the sulphinates) is also known. Treatment of (+)- or (−)-(**4**) with anhydrous HCl leads to (**3**) which is a stable crystalline solid and is of moderate stability in solution.§ Bromomethyl and iodomethyl ana-

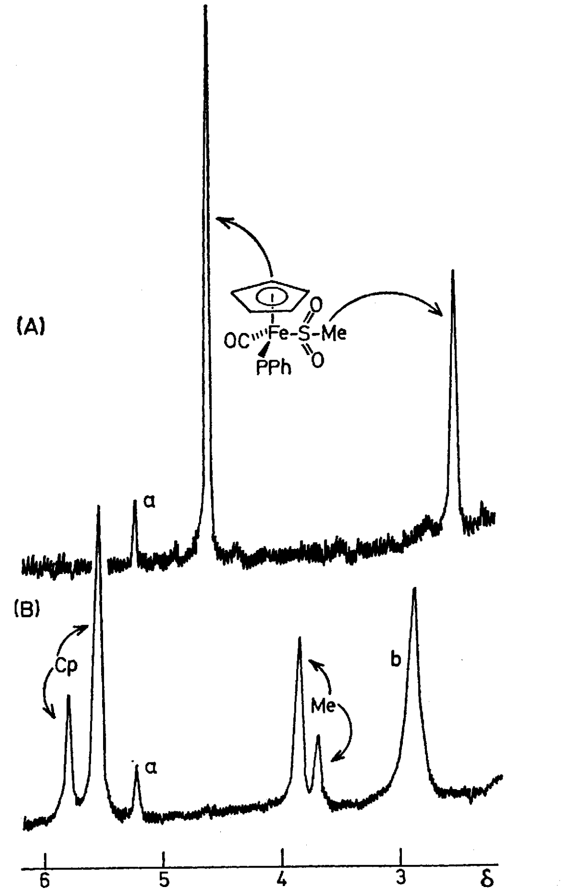


FIGURE. 100 MHz n.m.r. spectra of (A) (**6**; R = Me) and (B) (−)-(**6**; R = Me) with *ca.* 60% added racemic (**6**) and *ca.* 70% (w/w) added optically active shift reagent in CDCl$_3$. Resonance (a) is an impurity and (b) is a shift reagent peak.

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† Satisfactory elemental analyses for C and H, and consistent n.m.r. and i.r. spectra have been obtained for all new complexes reported.

‡ Davison and his co-workers (A. Davison, W. C. Krusell, and R. C. Michaelson, *J. Organometallic Chem.*, 1974, **72**, C7) have independently prepared (**4**) by a more circuitous route.

§ M–CH$_2$OMe chemistry has been studied in non-chiral systems (P. W. Jolly and R. Pettit, *J. Amer. Chem. Soc.*, 1966, **88**, 5044; M. L. H. Green, M. Ishaq, and R. N. Whiteley, *J. Chem. Soc.* (*A*), 1967, 1508), except for the alkylation reported here.

logues of (**3**) can be prepared similarly, and are increasingly unstable in solution in that order.

Compound (**3**) is an effective alkylating agent, reacting readily with various nucleophiles to form good yields of substituted methyliron derivatives of (**2**) (R = CN, OMe, *etc.*) which can be shown to be enantiomerically pure (see below).

TABLE

Physical properties of $[CpFe(CO)(PPh_3)R]$[a]

R	$[\alpha]_{578}^{25}$[b]	M.p./°C	Yield/%[c]
CH_2O(−)-(menthyl), (+)-(**4**)	+209	146—146·5	20[d]
(−)-(**4**)	−407	119—120	20[d]
CH_2Cl, (+)-(**3**)	+380	115[f]	75[e]
Me, (+)-(**5**)	+100	173—174	71
Et	+ 89	140—142[f]	78
Pr^n	+ 93	117·5—118	56
Bu^i	+ 71	—[g]	74
CH_2Ph	−165	79—83	63

[a] All data are for compounds having the configuration shown for (+)-(**3**) (Scheme 1) except for (−)-(**4**). [b] In benzene, *ca.* 2×10^{-3} M. [c] Based on starting (**3**) except where noted. [d] Based on $[CpFe(CO)_2]_2$. [e] Based on (**4**). [f] With decomposition. [g] Pure material would not crystallize.

Potentially the most useful reaction of (**3**) is that with organolithium and Grignard reagents wherein primary alkyls (**2**) are formed (see Table). Primary or secondary reagents give good yields, Grignard reagents giving higher yields than alkyl-lithiums. Tertiary RMgX or RLi produced the methyliron complex (**5**) almost exclusively. Typically, (**3**) dissolved in tetrahydrofuran (THF) at 0° is treated with RMgX (1·5—2 equiv.). After *ca.* 5 min at 0°, the mixture is warmed to 25°, solvent is removed, and chromatography on alumina provides pure product (frequently as an oil) which then can be crystallized in most cases. The methyliron complex (**5**) is formed in up to 70% yield by reduction of (**3**) with $NaBH_4$ in dimethoxyethane. Racemic (**3**) has also been used to prepare the cyclopropylcarbinyliron (**2**; R = cyclopropyl), and preparation of this from optically pure (**3**) is in progress.

The enantiomeric purity of all these alkyliron complexes is readily established as follows. SO_2 insertion into the Fe–C σ bond gives sulphinate derivatives (**6**)¶ (Scheme 2) and we have found that the sulphinate group interacts strongly with lanthanide n.m.r. shift reagents. The optically pure chiral shift reagent tris-[3-(trifluoromethylhydroxymethylene)-(+)-camphorato]europium(III) gives diastereoisomeric complexes with (**6**), leading to diastereoisotopic cyclopentadienyl resonances with distinct chemical shifts. *E.g.*, racemic (**6**; R = Me) exhibits resonances at δ 4·60 (Cp) and 2·52 (Me), while in the presence of *ca.* 70% (w/w) of shift reagent, the Cp resonance is a doublet centred at δ 5·65 ($\Delta\delta$ 0·24) and the methyl resonance is similarly a doublet centred at δ 3·78 ($\Delta\delta$ 0·17) (see Figure). Peak integration thus provides a direct measure of optical purity. All the complexes (**6**) have been prepared enantiomerically pure, and so the alkyls (**2**) and (**5**), the chloromethyl derivative (**3**), and the diastereoisomers of (**4**) are all optically pure.

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[1] H. Brunner, *Angew. Chem. Internat. Edn.*, 1971, **10**, 249.
[2] T. C. Flood and D. L. Miles, *J. Amer. Chem. Soc.*, 1973, **95**, 6460.
[3] T. C. Flood, D. L. Miles, C. K. Chou, and R. Bau, unpublished work.

¶ Both (**4**) and its $Fe-CH_2OMe$ analogue react abnormally with SO_2 to produce $[Fe-CH_2-(SO_3)$menthyl] and $[Fe-CH_2-(SO_3)Me]$. These derivatives serve equally well for optical assay using shift reagents. This C–O insertion is in contrast to the normal Fe–C insertion reported for $[CpFe(CO)_2CH_2OMe]$ (S. E. Jacobson and A. Wojcicki, *J. Amer. Chem. Soc.*, 1971, **93**, 2535). The unusual reactivity of (**4**) probably results from the increased stability due to the ligand L of the incipient or real intermediate $[CpFe^+(CO)$-$L(=CH_2)]$.