

## Preparation and Reactivity of $\eta^6$ -Pyridine Tricarbonyl Chromium Complexes

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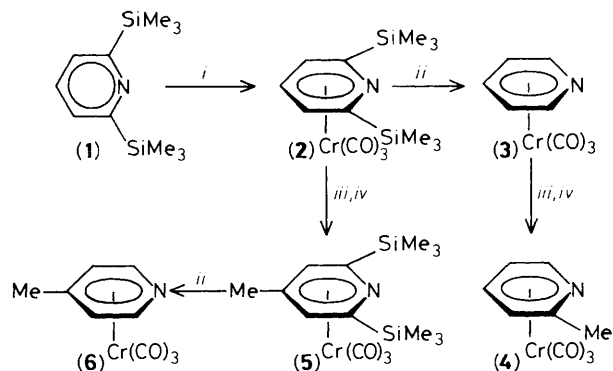
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Complexation of 2,6-bistrimethylsilylpyridine followed by desilylation generates  $\eta^6$ -pyridinetricarbonylchromium which undergoes regioselective deprotonation-methylation to give 2-methylpyridinetricarbonylchromium and regio- and stereo-selective nucleophilic additions of alkyl-lithiums to generate, after methylation, *N*-methyl-*exo*-2-alkyl-1,2-dihydropyridinetricarbonylchromium complexes.

Thermolysis of hexacarbonylchromium in the presence of pyridine gives trispyridinetricarbonylchromium with each pyridine being co-ordinated to the chromium through its nitrogen lone pair. The synthesis of  $\eta^6$ -pyridinetricarbonylchromium by this method is, therefore, precluded. However a few substituted  $\eta^6$ -pyridine<sup>1a-f</sup> and 1,2-dihydropyridine tricarbonylchromium<sup>2a-c</sup> complexes have been prepared by direct complexation although generally in low yield. Furthermore, owing to the lack of a viable synthetic method, the chemistry of  $\eta^6$ -pyridinetricarbonylchromium has not been

investigated. We report here the synthesis of  $\eta^6$ -pyridinetricarbonylchromium *via* the use of removable trimethylsilyl groups sterically to prevent co-ordination to the nitrogen lone pair.<sup>3</sup>  $\eta^6$ -Pyridinetricarbonylchromium undergoes regioselective lithiation and regio- and stereo-selective nucleophilic additions at the 2-position.

Thermolysis of hexacarbonylchromium with 2,6-bistrimethylsilylpyridine (**1**) in refluxing dioxane cleanly gave the novel yellow complex (**2**) in 75% yield. The electron withdrawing nature of the tricarbonylchromium moiety stabilises



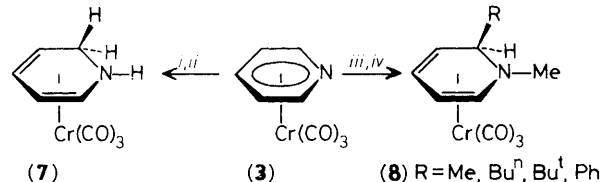
**Scheme 1.** Reagents and conditions: i,  $\text{Cr}(\text{CO})_6$ , dioxane, reflux; ii,  $\text{Bu}_4\text{NF}$ ,  $\text{H}_2\text{O}$ ; iii, lithium di-isopropylamide, THF,  $-40^\circ\text{C}$ ; iv, MeI.

co-ordinated aryl anions. Hence desilylation of complex (2) was readily achieved under mild conditions with aqueous tetrabutylammonium fluoride<sup>4</sup> to generate the yellow parent complex,  $\eta^6$ -pyridinetricarbonylchromium (3). Complexes (2) and (3) may be stored indefinitely in the dark, under an inert atmosphere at  $-20^\circ\text{C}$ . The  $\eta^6$ -co-ordination of the pyridine in complexes (2) and (3) was confirmed by the characteristic upfield shift of the ring protons in their  $^1\text{H}$  n.m.r. spectra.<sup>†</sup>

Complex (3) underwent regioselective 2-lithiation on treatment with lithium di-isopropylamide at  $-40^\circ\text{C}$  in tetrahydrofuran (THF). Trapping the intermediate 2-lithio derivatives with methyl iodide gave  $\eta^6$ -2-methylpyridinetricarbonylchromium (4).<sup>1a†</sup> The structure of (4) was unambiguously confirmed by an independent synthesis involving complexation and subsequent desilylation of 2-methyl-6-trimethylsilylpyridine. The acidity of the 2-protons in (3) is enhanced by the proximity of the electronegative nitrogen atom.

The trimethylsilyl groups on complex (2) prevent approach of lithium di-isopropylamide to the 3,5-protons and regioselective 4-lithiation occurs to yield, after trapping with methyl iodide, (5). Desilylation of complex (5) gave  $\eta^6$ -4-methylpyridinetricarbonylchromium (6).<sup>†</sup>

The electron withdrawing nature of the tricarbonylchromium moiety makes the pyridine ring in complex (3) susceptible to nucleophilic addition reactions.<sup>5</sup> Thus reduction of complex (3) with di-isobutylaluminium hydride (DIBAL) at  $-78^\circ\text{C}$  followed by methanol quenching regioselectively gave 1,2-dihydropyridinetricarbonylchromium (7)<sup>†</sup> as dark-orange blocks. Treatment of complex (3) with a range of alkyl-lithium reagents followed by quenching with methyl iodide resulted in the completely regio- and stereo-selective formation of the novel *N*-methyl *exo*-2-alkyl-1,2-dihydropyridinetricarbonylchromium complexes (8).<sup>†</sup> The formation of



**Scheme 2.** Reagents and conditions: i, DIBAL, toluene,  $-78^\circ\text{C}$ ; ii, MeOH; iii, RLi, THF,  $-78^\circ\text{C}$ ; iv, MeI.

complexes (8) results from addition of the nucleophile to the most electrophilic carbon from the uncomplexed face and trapping of the thus formed nitrogen based anion by methyl iodide.

The dihydropyridine complexes (7) and (8) have the stable 18-electron configuration at the metal: the dihydropyridine contributing six electrons, four from the  $\eta^4$ -diene, and two from the nitrogen lone pair. Quenching the initial adducts of alkyl-lithium addition with acetyl chloride instead of methyl iodide resulted in instant decomposition. Presumably in the transient *N*-acetyl complex the lone pair is withdrawn into the  $\pi$ -system of the acetyl and is no longer available for co-ordination to the chromium.

In contrast to their tricarbonylchromium complexes 1,2-dihydropyridines are very unstable in the free state.<sup>6</sup> The methodology described above allows the synthesis of these labile compounds as stable complexes from which the reactive 1,2-dihydropyridines may be liberated as required in the presence of appropriate trapping agents.<sup>7</sup>

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## References

- (a) E. O. Fischer and K. Ofele, *Chem. Ber.*, 1960, **93**, 1156; (b) P. L. Timms, *Angew. Chem., Int. Ed. Engl.*, 1975, **14**, 273; (c) H.-G. Biedermann, K. Ofele, N. Schuhbauer, and J. Tajtelbaum, *ibid.*, 1975, **14**, 639; (d) H.-G. Biedermann, K. Ofele, and J. Tajtelbaum, *Z. Naturforsch., Teil B*, 1976, **31**, 321; (e) K. Dimroth, R. Thamm, and H. Kaletsch, *ibid.*, 1984, **39**, 207; (f) R. E. Schmidt and W. Massa, *ibid.*, 1984, **39**, 213.
- (a) K. Ofele, *Angew. Chem., Int. Ed. Engl.*, 1967, **6**, 988; (b) K. Ofele, *J. Organomet. Chem.*, 1968, **12**, P42; (c) G. S. Huttner and O. S. Mills, *Chem. Ber.*, 1972, **105**, 3924.
- C. Eisenbroich, J. Koch, J. Kroker, M. Wansch, W. Massa, G. Baum, and G. Stork, *Chem. Ber.*, 1988, **121**, 1983.
- P. D. Baird, J. Blagg, S. G. Davies, and K. H. Sutton, *Tetrahedron*, 1988, **44**, 171.
- M. F. Semmelhack, J. L. Garcia, D. Cortes, R. Farina, R. Hong, and B. K. Carpenter, *Organometallics*, 1983, **2**, 467 and references therein.
- F. W. Fowler, *J. Org. Chem.*, 1972, **37**, 1321.
- C. A. Bear, W. R. Cullen, J. P. Kutney, V. E. Ridaura, J. Trotter, and A. Zandarotti, *J. Am. Chem. Soc.*, 1973, **95**, 3058; J. P. Kutney, R. Greenhouse, and V. E. Ridaura, *ibid.*, 1974, **96**, 7364; J. P. Kutney, M. Noda, and B. R. Worth, *Heterocycles*, 1979, **12**, 1269; J. P. Kutney, T. C. W. Mak, D. Mostowicz, J. Trotter, and B. R. Worth, *Heterocycles*, 1979, **12**, 1269; J. P. Kutney, T. C. W. Mak, D. Mostowicz, J. Trotter, and B. R. Worth, *ibid.*, 1979, **12**, 1517; J. P. Kutney, L. Kaczmarek, D. Mostowicz, and B. R. Worth, *Can. J. Chem.*, 1982, **60**, 323.

<sup>†</sup> All new compounds gave satisfactory elemental analyses, mass spectroscopic and n.m.r. data.  $^1\text{H}$  n.m.r. (300 MHz,  $\text{CDCl}_3$ ): (2)  $\delta$  5.48 (2H, d), 5.29 (1H, t), 0.33 (18H, s); (3)  $\delta$  6.56 (2H, dt), 5.65 (1H, tt), 5.26 (2H, m); (4)  $\delta$  6.60 (1H, d), 5.66 (1H, dt), 5.22 (1H, d), 5.15 (1H, m), 2.42 (3H, s); (5)  $\delta$  5.28 (2H, s), 2.09 (3H, s), 0.33 (18H, s); (6)  $\delta$  6.58 (2H, d), 5.15 (2H, d), 2.21 (3H, s); (7)  $\delta$  5.92 (1H, m), 5.82 (1H, m), 5.32 (1H, t), 3.75 (1H, m), 3.66 (1H, m), 3.21 (1H, d), 2.30 (1H, br. s); (8) (R = Me)  $\delta$  5.74 (1H, dt), 5.33 (1H, d), 5.17 (1H, dd), 3.92 (1H, m), 3.51 (1H, q), 2.55 (3H, s), 0.62 (3H, d).