

A Facile Synthesis of Ketones from Organoboranes using Pyridinium Fluorochromate†

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Pyridinium fluorochromate (PFC), in refluxing methylene dichloride, has been found to be an effective and convenient reagent for the oxidation of organoboranes to the corresponding ketones in good yield.

Oxidation of organoboranes with aqueous chromic acid is standard methodology for the synthesis of ketones.^{1–5} The use of diethyl ether, as the reaction solvent, was found to be an improvement in procedure and resulted in higher yields.^{2,6,7} More recently, pyridinium chlorochromate (PCC) has been used for the oxidation of organoboranes to the corresponding ketones^{8–10} and aldehydes.⁸ In the present study, we have developed a useful modification of this reaction, using pyridinium fluorochromate (PFC) in a non-aqueous reaction medium. Using PFC in refluxing methylene dichloride, we were able to achieve the conversion of organoboranes into the corresponding ketones in good yield.

The direct synthesis of ketones from organoboranes (produced from the hydroboration of olefins) represents a major transformation in organic chemistry. Improvements and modification in these methods can facilitate the chemical synthesis of these compounds.

In the present study, we have utilized the techniques of hydroboration to form organoboranes in high yields.^{12,13} The hydroboration of several olefins was conducted using borane–tetrahydrofuran complex (NH₃·THF). As expected, hydroboration of substrates **3**, **5**, **9** and **12** proceeded *via* anti-Markovnikov *cis* addition.^{11,12} In substrate **9**, *cis* addition from the less hindered side of the double bond gave **10** as the major product.¹³ We have found that the C-24 double bond of lanosterol acetate (**12**) selectively reacts with BH₃·THF to yield the C-24 organoborane. Oxidation of these resulting organoborane intermediates by PFC in refluxing methylene dichloride gave the ketones shown in Table 1.









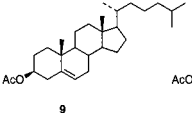
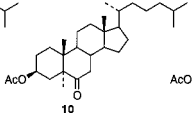
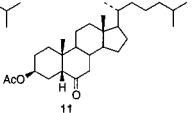
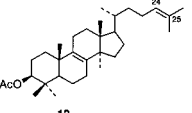
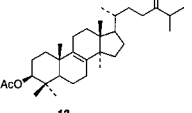
Pyridinium fluorochromate (PFC) is a mild and selective oxidant and has been used in the oxidation of a number of organic compounds.^{14,16} Representative ketones have been prepared from alkenes *via* hydroboration with BH₃·THF in order to demonstrate the generality of the oxidation of organoboranes with PFC. The high yields, anhydrous reaction conditions and easy work-up procedure make this a highly convenient method for the direct conversion of alkenes into ketones.

In summary, the reactions reported herein expand the scope and utility of synthetic transformations known to be accomplished by PFC and offer an alternative method for the synthesis of ketones from organoboranes.

Experimental

Hydroboration–Oxidation: General Procedure.—The olefins shown in Table 1 (9.5 mmol) were each dissolved in THF (75 ml) and cooled to 2 °C in an ice–water bath. While maintaining a nitrogen atmosphere a 1 M BH₃·THF solution (10 ml, 10 mmol) was added over a 10 min period. The reaction mixture was stirred for 1 h at 2 °C under nitrogen. Ice was then cautiously added to decompose the excess hydride, water was added, and the reaction mixture thoroughly extracted with diethyl ether. The extracts were dried over anhydrous MgSO₄ and evaporated at reduced pressure, toluene was added and the solvent evaporated at reduced pressure to remove traces of water (azeotrope). The residue was dried in a vacuum desiccator over P₂O₅ for 2 h and then dissolved in methyl-

Table 1 Hydroboration^a of olefins and oxidation of the resulting organoboranes to ketones by pyridinium fluorochromate (PFC)^b

Olefin substrate	Ketone product(s)	% Yield ^c
		78
		77
		76
		81
		74 and 9
		
		86

^aReactions were conducted at 2 °C in THF using BH₃·THF. ^bThe reactions were carried out in refluxing methylene dichloride.

^cYield of isolated ketone product.

ene dichloride (100 ml). PFC (15 g) and molecular sieves (100 mg; type 4A) were added and the reaction mixture was refluxed for 3 h. Saturated aqueous NaCl was added and the mixture thoroughly extracted with methylene dichloride. The solvent was removed at reduced pressure. Products **2**, **4** and **6** were purified by distillation, while products **8**, **10**, **11** and **13** were purified by column chromatography (using a solvent gradient of diethyl ether in toluene) to give the yields presented in Table 1. The procedures used for column and thin layer chromatography (TLC) have been described previously.¹⁷ The purified products **10**, **11** and **13** were recrystallized from acetone–water. All isolated reaction products were compared with authentic compounds^{9,10} and were confirmed by bnp or mp, IR, MS, ¹H and ¹³C NMR, and TLC.

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