

Specific Oxidative Cleavage of Allylic and Benzylic Ethers by Using Pyridinium Chlorochromate

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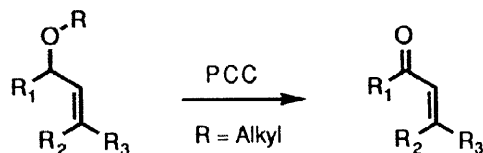
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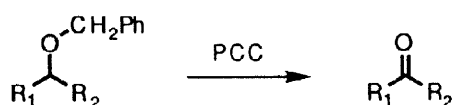
Abstract: The oxidation of alkoxyallylic ethers by PCC produces the corresponding α,β -unsaturated ketones or aldehydes and the oxidation of benzylic alcohols produces the corresponding ketones in satisfactory yields. © 1998 Published by Elsevier Science Ltd. All rights reserved.

The oxidative cleavage of ethers is a useful synthetic procedure. Unfortunately, it usually requires forceful conditions such as chromic acid/acetic acid¹, Jones reagent², cerium sulfate in acetic acid³ or silver oxide⁴. Trityl tetrafluoroborate⁵, nitronium⁶ and nitrosonium⁷ salts, ceric ammonium nitrate in the presence of sodium bromate⁸, UF₆⁹, metallic nitrates supported on silica gel¹⁰, dimethyldioxirane¹¹ or NO¹² have also been used to cleave oxidatively several alkyl ethers into the corresponding aldehydes or ketones. The search for mild, versatile, selective reagents for an operationally simpler transformation of ethers to alcohols or ketones has long been the objective of many research laboratories.

Before the studies of Corey and co-workers¹³, the reactivity of pyridinium chlorochromate (PCC) had been little investigated. PCC is well-known to convert alcohol into aldehydes or ketones with great efficiency¹⁴. With this reagent, tertiary cyclopropylcarbinols are transformed into the corresponding β,γ -unsaturated ketones¹⁵, and 1,4-dienes into dienones¹⁶, furan rings undergo oxidative ring enlargement¹⁷, quinones are obtained from hydroquinone silylethers¹⁸ and ketones from oximes¹⁹. PCC has also been reported to oxidize Δ^5 -3 β -tetrahydropyranyl ethers to the corresponding Δ^4 -3,6-diones²⁰. It was found, in the present study, that PCC in CH₂Cl₂ can convert allylic *o*-alkyl groups directly into the corresponding enones or α,β -unsaturated aldehydes and that benzyloxyethers are oxidized selectively into the corresponding aldehydes or ketones.



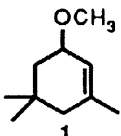
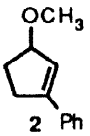
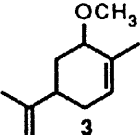
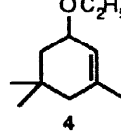
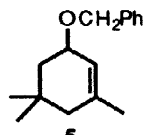
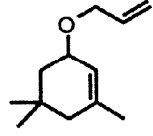
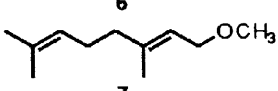
R₁, R₂ = alkyl; R₃, R₄ = alkyl or H; R = alkyl



R₁, R₂ = alkyl; R₁ = alkyl, R₂ = H; R₃ = benzyl

Thus, when compounds 1-7 were treated with 4 equivalents of PCC in refluxing CH_2Cl_2 (Table 1), they were converted into the corresponding α,β -unsaturated ketones or aldehydes.²¹ This reaction is independent of the nature of the alkoxy group. With secondary allylic ethers, the yields of enone formed were found to be generally better (typically 70 %-90 %, entries 1, 2, 4-6) than with primary allylic ethers (40 %, entry 7). In the case of compound 5, benzaldehyde was isolated in 60 % yield. The results are summarized in Table 1.

Table 1: Oxidation of allylic ethers

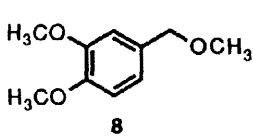
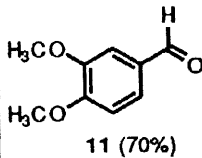
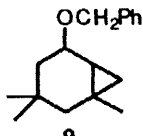
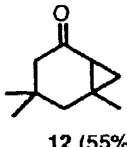
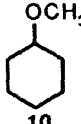
Entry	Starting Material	Time (h)	Conversion (%)	Corresponding enone or aldehyde (yield %)*
1		4	100	80
2		8	100	70
3		8	100	35
4		8	39	90
5		8	100	87
6		12	100	82
7		18	43	40

* Based on converted material

The oxidation of benzylic ethers by PCC (4 equiv.) in refluxing CH_2Cl_2 gave the corresponding ketones as exemplified by compounds 8 and 9 which were converted into 11 and 12 respectively in good yields. Interestingly, no oxidation was observed with ether 10. This suggests that benzylic or allylic stabilization of radical or/and cationic intermediates is required for a successful oxidation. When the cyclopropylcarbinyl ether 9 was treated by PCC, no ring opening was observed (Table 2). This is

consistent with the hypothetical formation of cyclopropylalkoxyalkyl cation intermediates that are much more stable than their isomeric homoallylic cations²².

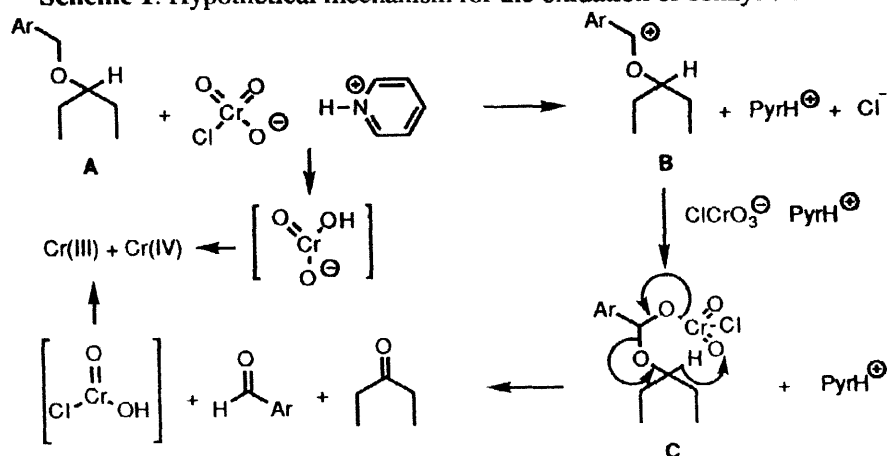
Table 2: Oxidation of benzyl ethers by PCC

Starting Material	Time (h)	Conversion (%)	Product (yield %)*
 8	4	100	 11 (70%)
 9	20	100	 12 (55%)
 10	10	0	—

* Based on converted material

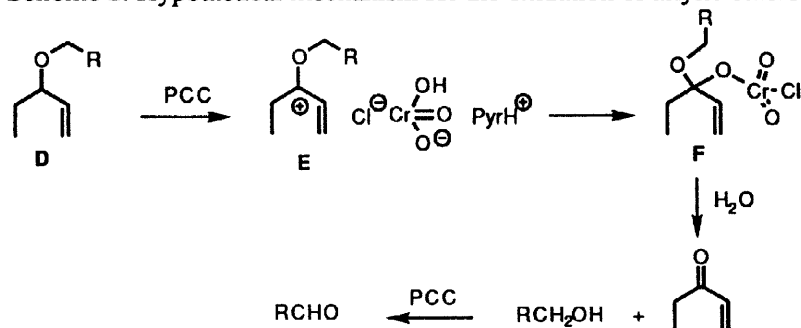
On the basis of the experimental data, we propose that the oxidation of benzylic ethers of type **A** undergo an hydride abstraction (or the equivalent) by the oxidant to produce in one (or several steps) the corresponding carbocation **B** which is trapped by the chlorochromate anion to produce **C**. Intermediate **C** then undergoes hydride transfer to produce the observed products and Cr(IV) species which dismutate into Cr(III) and Cr(IV) species (Scheme 1).

Scheme 1: Hypothetical mechanism for the oxidation of benzyl ethers



In the case of alkyl allylic ethers of type D, a related mechanism (Scheme 2) can be proposed. This mechanism implies the formation of an oxyallylic cation intermediate E. Quenching of this cation with the chloroformate anion generates an acylal which is then hydrolyzed to generate the observed products.

Scheme 2: Hypothetical mechanism for the oxidation of allylic ethers



In summary, our results demonstrate that PCC can be used advantageously in a one-step direct oxidation of allylic and benzylic ethers to give the corresponding ketones or aldehydes. This one-step conversion of ethers into ketones or aldehydes by PCC should find general application in organic synthesis.

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