



Selective oxidation of primary alcohols with chromium trioxide under solvent free conditions

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Received 3 July 2002; accepted 4 July 2002

Abstract—Selective oxidation of primary alcohols to the corresponding aldehydes by chromium trioxide under solvent free conditions are described. This new oxidation procedure is simple and affords good yields. © 2002 Elsevier Science Ltd. All rights reserved.

The oxidation of primary alcohols to the corresponding aldehydes is a transformation that is fundamental to synthetic organic chemistry, and numerous reagents and methods have been developed to carry out this important reaction.

Chromium trioxide (CrO₃)-based oxidants are one of the most widely used of all oxidising reagents for this transformation.^{1–4} Over the years they have been continually developed and modified to overcome the typical problems that occur during the oxidation and to accept wider ranges of substrates with improved selectivity. They have been accepted by synthetic chemists because they are readily available and easy to handle. However, the most important problem in their oxidations is that overoxidation can occur during the reaction process. In an attempt to circumvent this problem the trend has been to develop the use of complexes, supported reagents, and others, such as CrO₃–(pyridine)₂^{5,6} and CrO₃–(3,5-dimethylpyrazole)⁷ complexes; CrO₃ supported on resin,⁸ on graphite,⁹ on halosilane,^{10,11} on silica gel,^{12,13} on aluminium silicate,¹⁴ on kieselguhr,¹⁵ and on zirconium(IV) oxide;¹⁶ CrO₃ with diethyl ether,¹⁷ with crown ether,¹⁸ with *t*-butyl hydroperoxide,¹⁹ and with quaternary ammonium²⁰ species; CrO₃ in dimethyl formamide (DMF),²¹ in hexamethylphosphorous triamide (HMPT),^{22,23} and in dimethyl sulfoxide (DMSO)²⁴ systems. These procedures are mainly performed in neutral media and anhy-

drous conditions, since under acidic conditions the oxidation product and unreacted alcohol will react to give a hemiacetal that is rapidly oxidised to an ester, and in aqueous media the aldehyde product can be hydrated to the geminal diol that will be further oxidised.

In connection with our recent work on the solvent free oxidations,²⁵ we now report here that oxidation of primary alcohols with CrO₃ under solvent free conditions is a new system which offers a simple and efficient selective oxidation method for the preparation of aldehydes. In our experiments, the commercial CrO₃ without grinding and the 1.5 to 1 molar ratio of CrO₃ to substrate are employed. First oxidant is carefully added to a portion of the substrate and the mixture is stirred magnetically until TLC analysis indicates a completed reaction. Most reactions can be carried out at room temperature, but for solid substrates the reaction temperature should be near or above their melting points. In general, the oxidations are complete within 3–8 h. The reaction mixture is then worked up by filtration with dichloromethane or diethyl ether assisted by Celite or silica gel. Distillation of the solvent gives a product that is of acceptable purity for most purposes. If greater purity is required, the product can be distilled or recrystallised. The results, which are shown in Table 1, show that the method is generally applicable to a range of primary alcohols, and gives the corresponding aldehydes in good yields.

In summary, solvent free oxidation using CrO₃ as an oxidant is a new and efficient method for selective oxidation of primary alcohols.

Keywords: selective oxidation; primary alcohols; aldehydes; chromium trioxide; solvent free.

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Table 1. Solvent free chromium trioxide oxidations

$$\text{R-CH}_2\text{-OH} \xrightarrow{\text{CrO}_3, \text{R.T.}} \text{R-CHO}$$

Substrate ^a	Reaction time (h)	Product ^b	Yield (%)
<i>n</i> -C ₄ H ₉ -CH ₂ -OH	8	<i>n</i> -C ₄ H ₉ -CHO	60
<i>n</i> -C ₈ H ₁₇ -CH ₂ -OH	8	<i>n</i> -C ₈ H ₁₇ -CHO	62
	6		78
	3		90
	4		87
	4		83

^a For solid substrates the reaction temperature should be near or above their melting points.

^b All the aldehydes and ketones have been described previously in the literature and were identified by their IR spectra or by the IR spectra and melting points of their 2,4-dinitrophenylhydrazones.

Caution: CrO₃ is a highly toxic agent. All chromium(VI) reagents must be handled with care. The mutagenicity of chromium(VI) compounds is well documented.²⁶ Special care must always be exercised in adding CrO₃ to organic media. This oxidation is exothermic, and precautions should be taken to avoid it running amuck. Even though we have run each reaction at least three times on the amounts ranging from 0.100 to 0.300 g without encountering any problem, we nevertheless advise that any user should certainly never run on a large scale.

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