A Mild and Efficient Method for the Chemoselective Synthesis of Acylals from Aldehydes and their Deprotections Catalysed by Ceric Ammonium Nitrate

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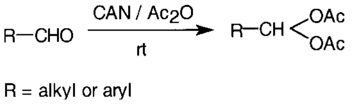
Abstract: A mild and efficient method has been developed for the chemoselective synthesis of *geminal* diacetates (acylals) from aldehydes using acetic anhydride in the presence of a catalytic amount of ceric ammonium nitrate in excellent yield. Ketones are found to be unaffected under the reaction conditions. The deprotections of acylals by using water and ceric ammonium nitrate have also been achieved.

Key words: acylals, aldehydes, chemoselective, ceric ammonium nitrate

Acylals (*geminal* diacetates) have been used as protecting groups for carbonyl compounds because of their stability in neutral and basic medium[1] as well as towards aqueous acids.[2] All these facts nicely complement the use of base stable acetals as aldehyde protecting groups. Acylals are important precursors for the preparation of acyloxydienes[3] and vinyl acetates[4] in Diels–Alder reaction and have been used as cross-linking reagents for cellulose in cotton.[5] Some industrial use of acylals have also been reported.[5,6]

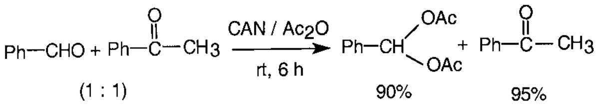
The reaction of aldehydes with acetic anhydride in presence of an acidic catalyst is the most common procedure for the preparation of acylals.[7] Different acidic catalysts for this conversion have been reported including strong protic acids[8] although the yields may in cases be poor and the required reaction time are quite long. Satisfactory results are also achieved by using protic acids[8,9] as well as by lewis acids[10] as catalyst. The use of solid acidic materials[8,11] in heterogeneous media have received attention as catalyst for the preparation of 1,1-diacetates because of their enhanced reaction rates and facile work-up procedures. Very recently, indium trichloride catalysed diacetoxylation of aldehydes has been reported.[12] Although some of these methods present convenient protocols with good to high product yields, it is noteworthy that except very few examples, most of the currently available methods suffer from mild to strong acidic conditions or require high temperature and catalyst loading. Many of these reagents are highly corrosive and difficult to handle while the triflates are rather expensive. Therefore the discovery of a novel, mild and catalytic methodology for the efficient transformation of aldehydes into acylals is still desirable. We report here a mild and efficient method for the preparation of 1,1-diacetates from aldehydes using acetic anhydride in the presence of a catalytic amount of ceric ammonium nitrate (CAN) without using any solvent.

Thus, the aldehydes on treatment with acetic anhydride (2 equiv) in the presence of CAN (10 mol%) at room temperature[13] afforded the corresponding diacetates in excellent yield (Scheme 1).



Scheme 1

Thus, a series of aldehydes were subjected to diacetoxylation reaction and the results are summarised in Table 1. Phenolic –OH group was also protected as acetate in the reaction conditions (entry 6 and 7, Table 1). Both aliphatic (2-hexanone, cyclohexanone) and aromatic (acetophenone, benzophenone) ketones did not respond to this reaction conditions. In a separate experiment, when a 1:1 mixture of benzaldehyde and acetophenone was allowed to react with acetic anhydride in the presence of a catalytic amount of CAN for 6 hours, benzaldehyde diacetate was isolated in about 90% yield and the unreacted acetophenone was isolated in 95% yield (Scheme 2).



Scheme 2

We also report here that the diacetates were deprotected to the corresponding aldehydes[14] in excellent yields by treatment with CAN (10 mol%) in the presence of water in acetonitrile at 70 °C for 5–7 hours (monitored by TLC) (Table).[15] It is noteworthy that the phenolic acetates were untouched in the reaction conditions (entry 6 and 7, Table).

In conclusion, we have developed a mild, efficient and chemoselective method for the preparation of *geminal* diacetates from both aromatic and aliphatic aldehydes using acetic anhydride in the presence of a catalytic amount of CAN without using any solvent. The ketones remained unaffected in the reaction conditions. We have also demonstrated that the diacetates were deprotected to the corre-

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Table 1 Diacetoxylation of Aldehydes Using Acetic Anhydride Catalysed by CAN and their Deprotection with CAN and Water

Entry	Starting Material	Yield (%)[a] of Acylals	Yield (%)[a] of Deprotection
1	Benzaldehyde	95 (1.5 h)[b]	90 (4 h)[b]
2	4-Methoxybenzaldehyde	90 (26 h)	90 (4.5 h)
3	3-Methoxybenzaldehyde	92 (6 h)	87 (4.5 h)
4	Piperonal	86 (24 h)	90 (4.5 h)
5	4-Chlorbenzaldehyde	97 (4 h)	90 (4.5 h)
6	Vanilin	94 (28 h)	91 (5.5 h)
7	3-Hydroxybenzaldehyde	90 (22 h)	88 (5.5 h)
8	Furfural	85 (23 h)	86 (4 h)
9	4-Nitrobenzaldehyde	96 (24 h)	89 (7 h)[c]
10	1-Naphthaldehyde	94 (4.5 h)	90 (5 h)
11	Acrolein	75 (4 h)	86 (4.5 h)
12	Crotonaldehyde	91 (2.5 h)	87 (4 h)
13	Cinnamaldehyde	96 (6 h)	91 (4 h)
14	Valeraldehyde	70 (28 h)	90 (4.5 h)
15	Caproaldehyde	70 (32 h)	89 (4 h)

[a] Yields to refer to chromatographically pure isolated product.

[b] Reaction time within parenthesis.

[c] 1.1 Equiv of CAN used.

sponding aldehydes in excellent yields using a catalytic amount of CAN and water at 70 °C.

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(13) **General Procedure for Acylation**: A solution of the aldehyde (1.13 mmol) in distilled acetic anhydride (2.26 mmol) was stirred with CAN (10 mol%) at r.t. under N_2. The progress of the reaction was monitored by TLC. After completion of the reaction, the mixture was quenched with sat. aq $NaHCO_3$ solution (4 mL) and was extracted with ether (3 × 25 mL). The combined organic layer was successively washed with sat. aq $NaHCO_3$ solution (3 × 10 mL), water (15 mL) and brine (20 mL) and then dried (Na_2SO_4). The solvent was removed under reduced pressure and the residue obtained that was column chromatographed over silica gel to obtain the pure acylal.

(14) **General Procedure for Deprotection**: A mixture of the acylal (1.0 mmol), CAN (10 mol%), water (2 mL) in acetonitrile (2 mL) was stirred at 70 °C under N_2. The progress of the reaction was monitored by TLC. After completion of the reaction, the mixture was diluted with brine (10 mL), extractited with ether (3 × 20 mL). The combined ether extract was washed with sat. aq $NaHCO_3$ solution (3 × 10 mL) and dried (Na_2SO_4). Solvent was removed under reduced pressure and the residue obtained was column chromatographed over silica gel to obtain the pure aldehyde.

(15) All the acylals prepared and the aldehydes obtained by the deprotection of the alylals were fully characterised by ^1H NMR and IR study and comparing the spectral data with those of authentic samples.