Cadmium Iodide Catalyzed and Efficient Synthesis of Acetals under Microwave Irradiations

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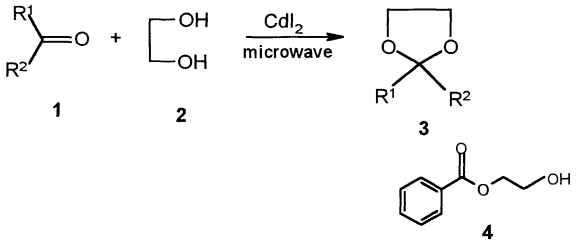
A new selective method of acetalization of aldehydes and ketones with 1,2-diols, 1,3-diols or alcohols mediated by cadmium iodide under microwave irradiation is achieved in excellent yields.

The use of microwave energy to activate organic reactions has been taking a new dimension very recently.[1,2] It has been used for a great variety of organic reactions such as esterification, etherification, oxidation, hydrolysis, Diels-Alder (4+2), Reformatsky, Knoevenagel and Bischler Napieralski reactions. Synthesis of derivatives which normally require long reflux periods can be achieved conveniently and very rapidly in a microwave oven.[3] However, there is no literature report on the application of microwave energy in the presence of cadmium iodide(CdI_2) for the synthesis of 1,3-dioxolanes. 1,3-Dioxolanes and 1,3-dioxanes are the most commonly used cyclic acetals and are generally prepared by reaction of the carbonyl group with ethane-1,2-diol or propane-1,3-diol in the presence of an acid catalyst.[4] Several methods have been developed for their preparations using TMSCl,[5] $BuSnCl_3$,[6] TsOH,[7] bis-trimethylsilyl ether of ethane 1,2-diol and trimethylsilyl triflate.[8] In a recent report[9] Cramarossa et al had reported the use of AlFe-Pillared montmorillonite catalyst for this purpose. But many of these methods require harsh reaction conditions, expensive reagents or poor yields and selectivity; consequently there is a need to develop new reagents for this reaction. Herein, in this letter we report the first example of the application of microwave energy in the presence of cadmium iodide,[10] a new and efficient catalyst for the chemoselective acetalization of carbonyl compounds in the presence of other substituent in a solvent free conditions. The reaction proceeds efficiently in excellent yields at ambient pressure within minutes time and in the absence of solvent.

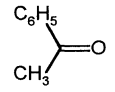
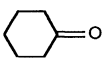
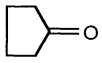
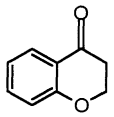
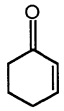
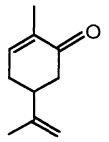
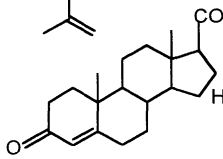
In a typical case, a mixture of benzaldehyde (1.06 g, 10 mmol), ethane-1,2-diol (0.62 g, 10 mmol) and commercial grade cadmium iodide[11] (1.85 g, 5 mmol) were thoroughly mixed at room temperature in an Erlenmeyer flask and placed in a commercial microwave oven operating at 2450 MHz frequency. After irradiation of the mixture for 1.5 min (monitored vide tlc) it was cooled to room temperature, extracted with dichloromethane, washed with sodium thiosulfate and dried over anhydrous Na_2SO_4. Evaporation of the solvent gave almost pure products **3a** and there was no evidence for the formation of any



1 2 3 4

Scheme 1.

Table 1. Microwave Induced Acetalization with CdI_2

Pro-duct	Aldehyde/ketone 1	alcohol 2	Reaction time/min MW	Yield % MW	Yield % Lit
3a	PhCHO	$HO(CH_2)_2OH$	1.5	90	70[14]
3b	PhCHO	$HO(CH_2)_3OH$	1.5	85	88[15]
3c	4-ClC_6H_4CHO	$HO(CH_2)_2OH$	2.0	92	-
3d	4-$NO_2C_6H_4CHO$	$HO(CH_2)_2OH$	2.0	90	-
3e	CH_3CH=$CHCHO$	$HO(CH_2)_2OH$	1.5	85	87[7]
3f	PhCH=CHCHO	$HO(CH_2)_2OH$	2.0	82	97[7]
3g		$HO(CH_2)_2OH$	2.5	85	-
3h	PhCOCHO	MeOH	2.5	80	83[16]
3i		MeOH	2.0	85	95[16]
3j		C_2H_5OH	1.5	85	75[17]
3k		C_2H_5OH	2.5	80	75[17]
3l		$HO(CH_2)_2OH$	2.0	75	-
3m		$HO(CH_2)_2OH$	2.0	80	-
3n[a]		$HO(CH_2)_2OH$	2.5	75	30[18]

[a]3n is a monoacetal.

hydroxy ester **4** or iodoester. Further purification was achieved by column chromatography on silica gel using 1:5 chloroform :pet.ether as the eluent.

Similarly other aldehydes and ketones were allowed to react with diols and alcohols for 1.5-2.5 min in the presence of CdI_2 under microwave activation The acetalization proceeded rapidly, giving the corresponding acetals in excellent yields (Table 1). When α,β-unsaturated carbonyl compounds were reacted with diols under the same conditions, the carbonyl group was

selectively acetalized to give the corresponding acetals in 75-82% yields. Thus carvone under similar reaction conditions yielded its acetal whereas in case of 2-cyclohexenone a typical α,β-unsaturated ketone is facilely acetalized without concomitant double bond migration. For α-dicarbonyl compounds, this procedure provides a way to selectively monoacetalized the more activated carbonyl group. Thus phenylglyoxal was converted to the corresponding dimethylacetal in 80% yield. To check the efficiency of the microwave energy we have carried out the acetalization of carbonyl compounds under thermal heating[12] in the presence of cadmium iodide, and found that the reaction is comparatively less effective and takes about 45-60 min. in 50-60% yields. Further increasing the reaction time had no significant effect on the yield and resulted in minor amount of decomposition. Interestingly, when the same reaction was carried out under microwave activation in the absence of cadmium iodide for 15 min, the reaction did not yield any product and the starting materials were recovered. Furthermore, it was also observed that the presence of solvent slowered the reaction when carried out in THF, the reasons for the efficiency of the process on the solid phase are not yet clear. All the compounds obtained were characterised by IR, ^{1}H NMR and MS spectra and finally by comparison with authentic samples.

In summary this new method of acetal formation using cadmium iodide without any solvent under microwave irradiation offers significant improvements over the existing procedures and thus help facile entry into a variety of acetals of potentially high synthetic utility.[13] Also this simple and easily reproducible technique affords various acetals in shorter reaction time, with excellent yields without involvement of expensive material, nonrequirement of dry solvent and water removal technique, and without the formation of any side products, than the classical homogeneous reaction in solvents.

References and Notes

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