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Synthesis of aromatic aldehydes via $NiCl_2$ reduction and hydrolysis of oxazolines

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Abstract—Reduction of 2-aryl-oxazolines with $NiCl_2/NaBH_4$ followed by hydrolysis gives the corresponding aldehydes in good yields.

1. Introduction

Undoubtedly, the aldehyde functionality occupies a central position in synthesis being able not only to accept electrophiles but also to have reversed polarity (umpolung) after derivatisation as a cyanohydrin, dithioacetal, dithiane or α-aminonitrile derivative.[1] It is not surprising therefore, that a large number of procedures[2] have been introduced to generate this functionality ranging from oxidation of functional groups such as alcohols, ethers, halides and alkenes or reduction of carboxylic acids and their derivatives. Of these, the direct reduction of a carboxylic acid to an aldehyde is difficult to achieve. Different reagents, which have been used for this transformation are lithium in dimethylamine,[3] thexyl borane,[4] 2-thiazoline-2-thiol,[5] *iso*-butylmagnesium bromide/dichloro bis(*n*-cyclopentadienyltitanium),[6] bis(4-methylpiperazinyl)aluminium hydride,[7] etc. In addition, a number of procedures are known for the reduction of carboxylic acids to the corresponding aldehydes, including reduction with thexylchloroborane–methyl sulfide,[8] lithium aluminum hydride reduction to the primary alcohol followed by reoxidation to the aldehyde, preparation of various acid derivatives followed by reduction with Dibal-H,[9] cyclic dialkyldiaminoaluminium hydride,[10] dichlorobis(cyclopentadienyl)titanium-catalysed Grignard reactions[8] all of which need laborious work-up and further isolation of the product. This prompted us to use the simple easily available reagent, $NiCl_2/NaBH_4$ for the conversion of carboxylic acids to the corresponding aldehydes via oxazoline ring formation.

Benzoic acid was converted into the corresponding oxazoline using a literature method.[11] The oxazoline was treated with $NiCl_2/NaBH_4$ at −10 °C followed by hydrolysis with 5% aq HCl to give the corresponding aldehyde in 90% yield. This encouraging result prompted us to study some other commercially available aromatic acids and indeed excellent yields of the corresponding aldehydes were obtained (Table 1). Unfortunately reduction of the oxazoline derived from propanoic acid under identical conditions gave only a very low yield of propanal. All the products prepared were identical by bp or mp and by IR and NMR spectroscopy with known aldehydes.[12]

2. General procedure for the preparation of benzaldehyde from benzoic acid

In the first step of the reaction, 2-phenyl-2-oxazoline (5 mmol, 0.735 g) and $NiCl_2$ (2.37 g, 10 mmol) were taken in methanol and cooled to −10 °C. Sodium borohydride (0.74 g, 20 mmol) was added in small amounts over 30 min whilst maintaining the temperature at −10 °C. The mixture was then kept at 10 °C for a further 30 min to complete the reaction. The reaction mixture was filtered through Celite and the solvent evaporated under vacuum. The residue was treated with 5% HCl (10 mL) at 40 °C for 10–15 min, then cooled to room temperature and extracted with diethyl ether (25 mL).

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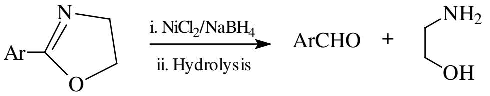
Table 1.



a) Ar=C_6H_5; b) Ar=*p*-CH_3-C_6H_4; c) Ar=*p*-CH_3O-C_6H_4; d) Ar=3,4-$(CH_3O)_2C_6H_3$;
e) Ar=*p*-Cl-C_6H_4; f) Ar=*m*-Br-C_6H_4; g) Ar=*o*-NO_2-C_6H_4; h) Ar=*p*-Me_2N-C_6H_4;

Entry	Oxazoline	Aldehyde	Bp/Mp (°C)		Yield(%)
			Found	Reported[12]	
1	a	Benzaldehyde	178–179	179	90
2	b	*m*-Tolualdehyde	197–198	199	89
3	c	Anisaldehyde	247–248	248	91
4	d	Veratraldehyde	284–285	285	92
5	e	*p*-Chlorobenzaldehyde	213–214	214	88
6	f	*m*-Bromobenzaldehyde	233–234	234	89
7	g	*o*-Nitrobenzaldehyde	44–45	44	90
8	h	*p*-Dimethylamino benzaldehyde	73–74	74	87

The organic layer was washed with water, dried over anhydrous sodium sulfate and evaporated under vacuum to give benzaldehyde as a colourless oily liquid in 90% yield (0.477 g).

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