

## Potash alum [KAl(SO<sub>4</sub>)<sub>2</sub>·12H<sub>2</sub>O] catalysed esterification of formylphenoxyaliphatic acids

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MS received 23 November 2011; revised 6 March 2012; accepted 8 March 2012

**Abstract.** A convenient and clean procedure for esterification is reported. Direct condensation of formylphenoxyaliphatic acids with low to high boiling alcohols catalysed by potash alum gave moderate to good yields. This catalyst could be recovered and reused without substantial loss in its catalytic activity and the methodology could be used for a range of closely related substrates.

**Keywords.** Esterification; formylphenoxyaliphatic acids; potash alum; phenoxyaliphatic acid ester and catalyst reuse.

### 1. Introduction

Carboxylic acid esters find wide industrial applications in the synthesis of drugs, drug intermediates, fine chemicals, and auxiliary agents like flavouring agents, polymers, fatty acids, and paints.<sup>1</sup> Phenoxyaliphatic acid ester derivatives exhibit antimicrobial, antibacterial, and antitumour activity,<sup>2</sup> and display inhibitor activity such as aldose reductase (A),  $\alpha$ -asarone-based HMG-CoA reductase (B), tyrosinase, acetylcholinesterase (C and D) (figure 1) and behave as PPAR  $\delta$ -selective agonists.<sup>3</sup> Due to the versatile application possibilities of phenoxyaliphatic acid ester derivatives, there is a continuous quest for more efficient methods for the synthesis of aryloxyaliphatic acid esters.

Conventionally, the esterification processes have been carried out with excess loading of limited acid-tolerant reagent classes in the presence of strong acid activators eg., sulphuric acid, boric acid,<sup>4</sup> solid supported super acid,<sup>5</sup> Lewis acid,<sup>6</sup> etc. where environmental (moisture sensitive, corrosive, or toxic) anxieties are yet to be addressed. However, the difficulty arises due to the reversibility of the reaction; one of the reactants is used as excess for the continuous removal of water formed to drive the reaction equilibrium toward the product. Some of the reported methodologies still require heating (azeotropic water removal) in solvents

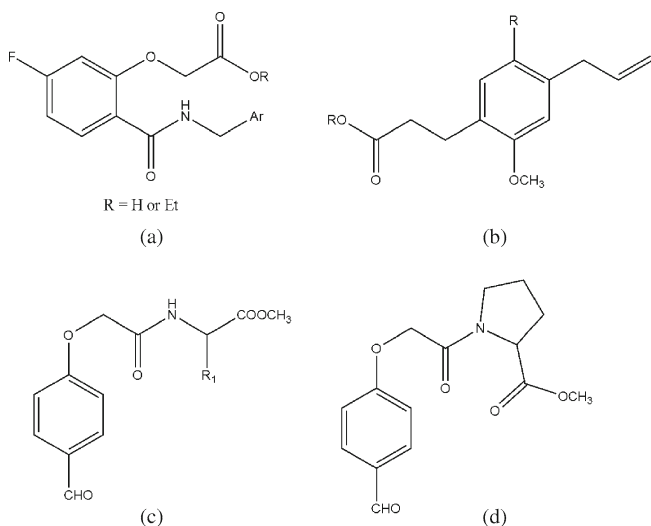
such as *o*-xylene, 1,3,5-mesitylene, or toluene<sup>7</sup> as well as dehydrating agents.<sup>7a,d</sup> A great deal of research focuses on more environmentally benign alternatives for esterification reaction.

Continuous investigations for catalysts to maximize the advantages and minimize the limitations have been in search. We were influenced by the awareness of the use of solid acids as environmentally friendly approaches in organic synthesis. In pursuit of designing/choosing a suitable catalyst system, we realized that the usual homogenous catalysts are often destroyed during product isolation and this 'once through' utilization of the catalyst can result in high manufacturing costs. A heterogeneous catalyst system, on the other hand, may be easily recovered by filtration and recycled. In this case the extra processing steps are eliminated and the cost on catalyst discarding is minimized.

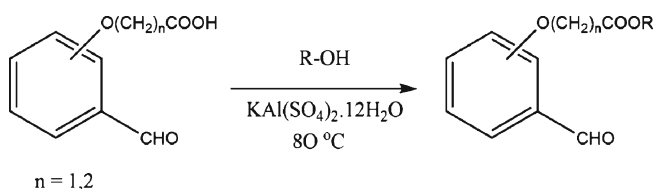
Esterification of aromatic/aliphatic acids with ethanol/methanol under solvent-free condition was reported.<sup>8</sup> This prompted us to initiate a systematic investigation to look into the feasibility of less hazardous, solvent-free synthesis of formylphenoxyaliphatic acids under modified experimental conditions towards development of a green methodology.

Potash alum [KAl(SO<sub>4</sub>)<sub>2</sub>·12H<sub>2</sub>O] is being exploited in many organic syntheses<sup>9</sup> and transesterification of palm oil for its use as biodiesel.<sup>10</sup> It is a mild Lewis acid, non-volatile, non-corrosive, and insoluble in common organic solvents. It is economical and easy to handle. We report here the esterification of formylphenoxyaliphatic acids with aliphatic alcohol using potash alum as a catalyst (scheme 1).

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**Figure 1.** Selected examples of biologically important phenoxyaliphatic acid esters.



**Scheme 1.** Synthesis of formylphenoxyalkyl acid ester.

## 2. Experimental

All chemicals were purchased from Merck, Himedia and Sigma-Aldrich chemical companies. Alcohols were distilled and used. Melting points were measured in open capillary tubes and are uncorrected. Silica gel-G plates (Merck) were used for TLC analysis with a mixture of *n*-hexane and ethyl acetate as eluent. The  $^1\text{H}$  NMR, and  $^{13}\text{C}$  NMR spectra were recorded on a Bruker (Avance) 300 MHz NMR instrument using TMS as internal standard and  $\text{CDCl}_3$  as solvent. Standard Bruker software was used throughout. Chemical shifts are given in parts per million ( $\delta$  scale) and the coupling constants are given in Hertz. Infrared spectra were recorded on a JASCO FT-IR Model 410 spectrophotometer (in KBr pellet). Band positions are reported in reciprocal centimetres ( $\text{cm}^{-1}$ ). The DART-MS was recorded on a JEOL-AccuTOF JMS-T100LC Mass spectrometer having a DART (Direct Analysis Real Time) source. Elemental analyses were performed on a Perkin Elmer 2400 Series II Elemental CHNS analyzer.

### 2.1 Purification of potash alum

Potash alum was powdered well in mortar and washed repeatedly with absolute ethanol for removing the traces of sulphuric acid. The solid was again washed many times with dry acetone. Then the solid was dried under vacuum at  $60^\circ\text{C}$ . The dried solid was preserved in a calcium chloride dessicator.

### 2.2 General procedure for the synthesis of formylphenoxyalkyl esters

Formylphenoxyacetic acid/formylphenoxypropionic acid (5 mmol), alcohol (12.5 mmol), and potash alum (10 mol%) were mixed and stirred at  $80^\circ\text{C}$  for 12 h. Completion of the reaction was monitored by TLC. The reaction mixture was cooled to room temperature and the catalyst was filtered through a cotton plug. The excess solvent was evaporated under vacuum. The product was dissolved in ethyl acetate and washed with 5% sodium bicarbonate solution to remove any unreacted acid. The organic layer was separated and dried with anhydrous sodium sulphate. After evaporation of the solvent under vacuum, a semi-solid/liquid was obtained which solidified at cold temperature.

The spectral data of formylphenoxyalkyl esters (**2a-f**) are summarized below:

**2.2a Ethyl 2-(2-formylphenoxy)acetate (2a):** Brown semi-solid, 92% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.32 (t,  $J = 12.9$  Hz, 3H), 4.03 (q,  $J = 21.3$  Hz, 2H), 4.76 (s, 2H), 6.87 (d,  $J = 8.4$  Hz, 1H), 7.08 (t,  $J = 7.5$  Hz, 1H), 7.17 (t,  $J = 7.8$  Hz, 1H), 7.88 (d,  $J = 7.8$  Hz, 1H), 10.60 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 61.5, 65.6, 112.6, 121.8, 125.4, 128.5, 135.6, 160.1, 168.1, 189.5, FT-IR (KBr): 1752, 1683,  $1594\text{ cm}^{-1}$ . DART-MS: 209.08 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{11}\text{H}_{12}\text{O}_4$ : C 63.45, H 5.81%. Found: C 63.42, H 5.83%.

**2.2b Ethyl 2-(2-formylphenoxy)propionate (2b):** Brown liquid, 92% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.33 (t,  $J = 14.1$  Hz, 3H), 2.87 (t,  $J = 12.3$  Hz, 2H), 4.16 (q,  $J = 21.3$  Hz, 2H), 4.28 (t,  $J = 12.6$  Hz, 2H), 6.98–7.05 (m, 2H), 7.52 (t,  $J = 7.8$  Hz, 1H), 7.81 (d,  $J = 6.3$  Hz, 1H), 10.53 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 14.0, 34.3, 60.8, 64.1, 112.6, 120.9, 124.9, 128.1, 135.8, 160.8, 170.6, 189.5, FT-IR (KBr): 1735, 1685,  $1596\text{ cm}^{-1}$ , DART-MS: 223.09 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{12}\text{H}_{14}\text{O}_4$ : C 64.85, H 6.35%. Found: C 64.89, H 6.37%.

2.2c *Ethyl 2-(4-formylphenoxy)acetate (2c)*: Sandal semi-solid, 94% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.29 (t, 3H), 4.28 (q, 2H), 4.71 (s, 2H), 7.01 (d,  $J = 8.7$  Hz, 2H), 7.84 (d,  $J = 5.1$  Hz, 2H), 9.89 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 14.0, 61.5, 65.1, 114.7, 130.6, 131.8, 162.5, 167.9, 190.5. FT-IR (KBr): 1754, 1675, 1601  $\text{cm}^{-1}$ , DART-MS: 208.12 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{11}\text{H}_{12}\text{O}_4$ : C 63.45, H 5.81%. Found: C 63.42, H 5.86%.

2.2d *Ethyl 2-(4-formylphenoxy)propionate (2d)*: Brown semi-solid, 95% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.28 (t,  $J = 14.1$  Hz, 3H), 2.83 (t,  $J = 12.6$  Hz, 2H), 4.02 (q,  $J = 21.3$  Hz, 2H), 4.34 (t,  $J = 12.6$  Hz, 2H), 7.01 (d,  $J = 8.7$  Hz, 2H), 7.83 (d,  $J = 8.7$  Hz, 2H), 9.88 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 14.0, 34.2, 60.7, 63.6, 114.7, 130.1, 131.8, 163.4, 170.5, 190.6. FT-IR (KBr):  $\nu_{\text{max}}$  1734, 1691, 1600  $\text{cm}^{-1}$ , DART-MS: 223.09 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{12}\text{H}_{14}\text{O}_4$ : C 64.85, H 6.35%. Found: C 64.79, H 6.41%.

2.2e *Ethyl 2-(4-formyl-2-methoxyphenoxy)acetate (2e)*: Sandal semi-solid, 96% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.28 (t,  $J = 14.1$  Hz, 3H), 3.96 (s, 3H), 4.28 (q,  $J = 21.3$  Hz, 2H), 4.78 (2H, s), 6.9 (d,  $J = 8.1$  Hz, 1H), 7.41–7.45 (m, 2H), 9.86 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 14.0, 56.0, 61.5, 65.9, 109.9, 112.4, 126.0, 131.1, 149.9, 152.5, 167.9, 190.7. FT-IR (KBr):  $\nu_{\text{max}}$  1752, 1680, 1591  $\text{cm}^{-1}$ , DART-MS: 239.09 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{12}\text{H}_{14}\text{O}_5$ : C 60.50, H 5.92%. Found: C 60.56, H 5.96%.

2.2f *Ethyl 2-(4-formyl-2-methoxyphenoxy)propionate (2f)*: Sandal semi-solid, 96% yield,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ): 1.27 (3H,  $J = 14.1$  Hz, t), 2.90 (t,  $J = 10.2$ , 2H), 3.92 (s, 3H), 4.20 (q,  $J = 21.3$  Hz, 2H), 4.40 (t,  $J = 6.9$  Hz, 2H), 7.04 (d,  $J = 8.1$  Hz, 1H), 7.41–7.43 (m, 2H), 9.86 (s, 1H),  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ): 14.1, 34.2, 55.9, 60.8, 64.5, 109.6, 112.0, 126.5, 130.4, 149.9, 153.5, 170.5, 190.8. FT-IR (KBr):  $\nu_{\text{max}}$  1721, 1685, 1590  $\text{cm}^{-1}$ , DART-MS: 253.10 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{13}\text{H}_{16}\text{O}_5$ : C 61.90, H 6.39%. Found: C 61.96, H 6.41%.

2.2g *Methyl 2-(2-formylphenoxy)acetate (2g)*: Sandal semi-solid, 92% yield,  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ): 3.82 (s, 3H), 4.78 (s, 2H), 6.86 (d,  $J = 8.0$  Hz, 1H), 7.09 (t,  $J = 16.0$  Hz, 1H), 7.54 (t,  $J = 15.6$  Hz, 1H), 7.88 (d,  $J = 7.6$  Hz, 1H), 10.57 (s, 1H), DART-MS: 195.07 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{11}\text{H}_{12}\text{O}_4$ : C 61.85, H 5.19%. Found: C 61.82, H 5.14%.

2.2h *n-Butyl 2-(2-formylphenoxy)acetate (2h)*: Yellowish liquid, 88% yield,  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ): 0.88 (t,  $J = 14.8$  Hz, 3H), 1.31 (m, 2H), 1.59 (p,  $J = 14.8$  Hz, 2H), 4.18 (t,  $J = 13.2$  Hz, 2H), 4.74 (s, 2H), 6.86 (d,  $J = 8.0$  Hz, 1H), 7.09 (t,  $J = 15.6$  Hz, 1H), 7.60 (t,  $J = 15.6$  Hz, 1H), 7.83 (d,  $J = 8.0$  Hz, 1H), 10.53 (s, 1H), DART-MS: 237.12 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{11}\text{H}_{12}\text{O}_4$ : C 66.09, H 6.83%. Found: C 66.12, H 6.85%.

2.2i *n-Hexyl 2-(2-formylphenoxy)acetate (2i)*: Yellowish liquid, 89% yield,  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ): 0.88 (t,  $J = 14.8$  Hz, 3H), 1.31–1.28 (m, 4H), 1.65–1.59 (m, 4H), 4.20 (t,  $J = 13.6$  Hz, t), 4.74 (s, 2H), 6.86 (d,  $J = 8.4$  Hz, 1H), 7.09 (t,  $J = 15.2$  Hz, 1H), 7.53 (t,  $J = 16.0$  Hz, 1H), 7.87 (d,  $J = 7.6$  Hz, 1H), 10.57 (s, 1H), DART-MS: 265.15 (M + H) $^+$ , Anal.Calcd. for  $\text{C}_{11}\text{H}_{12}\text{O}_4$ : C 68.16, H 7.63%. Found: C 68.12, H 7.58%.

2.2j *Isopropyl 2-(4-isobutylphenyl)propanoate (3a)*: Yellowish liquid, 72%,  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ): 0.89 (d,  $J = 6.50$  Hz, 6H), 1.13 (d,  $J = 6.50$  Hz, 6H), 1.21 (d,  $J = 6.00$ , 3H), 1.85 (m, 2H), 2.44 (d,  $J = 7.50$  Hz, 1H), 3.65 (q,  $J = 21.5$  Hz, 1H), 4.98 (m, 1H), 7.08 (d,  $J = 8.00$  Hz, 2H), 7.19 (d,  $J = 8.00$  Hz, 2H).

2.2k *Butyl 2-(4-isobutylphenyl)propanoate (3b)*: Yellowish liquid, 78%,  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ): 0.87 (t,  $J = 14.8$  Hz, 3H), 0.89 (d,  $J = 6.50$  Hz, 6H), 1.28 (m, 2H), 1.48 (d,  $J = 7.50$  Hz, 3H), 1.55 (m, 2H), 1.84 (m, 1H), 2.44 (d,  $J = 7.00$  Hz, 2H), 3.65 (q,  $J = 12.50$  Hz, 1H), 4.06 (t,  $J = 13.50$  Hz, 2H), 7.08 (d,  $J = 8.00$  Hz, 2H), 7.20 (d,  $J = 8.00$  Hz, 2H).

### 3. Results and discussion

We have synthesized formylphenoxyacetic/propionic acids from phenolic aldehydes and the appropriate chlorocarboxylic acids.<sup>11</sup> The effects of process parameters such as catalyst concentration, reaction temperature, reaction time, and reusability of catalyst on the esterification have been investigated.

#### 3.1 Effect of mole ratio of alcohol

Esterification reactions involve the importance of the alcohol to carboxylic acid mole ratio as one of the main factors influencing the reactions.<sup>12</sup> Excess alcohol does favour the formation of alkyl esters. In order to find the stoichiometry of alcohol to acid, we initially carried out the esterification reaction with 2-formylphenoxyacetic

acid (1.0 mmol) (**1a**) with different molar concentrations of absolute ethanol/*n*-butanol using potash alum (50 mol%) under reflux for 24 h. It has been observed that the presence of excess ethanol/*n*-butanol (2.5 mmol) leads to the formation of ethyl/butyl 2-(2-formylphenoxy)acetate in an excellent yield (94/88%, respectively) [for details, see the [electronic supplementary material](#)].

### 3.2 Effect of catalyst loading

When the esterification reaction was carried out with 0.1–1.0 mol% of the catalyst, potash alum, only trace amounts of the products were formed after 24 h reflux. Excellent (92–94%) conversion to ethyl 2-(2-formylphenoxy)acetate was observed with 10–50 mol% of potash alum after 24 h. No significant improvement in conversion was observed with a higher catalyst loading (up to 1 equivalent) and extension of reaction time (48 h). In order to use the minimum mass of the catalyst, we found that 10 mol% of potash alum was optimum for the completion of reaction. So we have limited the catalyst to 10 mol% for the continuation of this study.

### 3.3 Reaction temperature, reaction time, and necessity of catalyst

To find the optimum reaction temperature for this esterification we considered the following set of model reactions. Reactions of **1a** were performed with absolute

ethanol and *n*-butanol in the presence of 10 mol% potash alum. The results are given in table 1.

By increasing the reaction temperature the yield of the esters increases. The optimum temperature was observed at 80°C. In low boiling alcohol (ethanol), acid (**1a**) dissolved immediately even before warming and adding potash alum. But in the case of *n*-butanol, acid (**1a**) dissolved in the presence of potash alum (10 mol%) at 80°C.

Prolonging the esterification reaction of **1a** with *n*-butanol for 48 h seemed to cause neither decomposition of the reactant acid nor reversibility of the reaction. This indicates the selectivity of potash alum for the esterification of these acids.

Removal of potash alum from the reaction mixture after 6 h did not improve the yield of the esters indicating its role as a heterogeneous catalyst for the progress of the reaction [see the [electronic supplementary information](#) for details].

### 3.4 Effect of solvent

We planned to determine the influence of a few solvents on the catalytic efficiency of potash alum (10 mol%) during the reaction of the acid (**1a**, 5 mmol) with *n*-butanol (12.5 mmol). The presence of solvent was found to have a detrimental impact on the yield of the corresponding ester. Azeotropic water removal did not help the reaction in dichloromethane whereas benzene afforded a moderate yield (56%). In order to use

**Table 1.** Esterification<sup>a</sup> of **1a** with ethanol/*n*-butanol catalysed by potash alum under solvent-free conditions.

Acids	Alcohols	Reaction temperature (°C)	Reaction time (h)	Isolated yield <sup>b</sup> (%)
<b>1a</b>	Ethanol	30	24	Nil
<b>1a</b>	Ethanol	60	24	78
<b>1a</b>	Ethanol	80	12	92
<b>1a</b>	Ethanol	100	12	92
<b>1a</b>	<i>n</i> -butanol	30	24	Nil
<b>1a</b>	<i>n</i> -butanol	60	24	Trace
<b>1a</b>	<i>n</i> -butanol	80	48	88
<b>1a</b>	<i>n</i> -butanol	80	24	88
<b>1a</b>	<i>n</i> -butanol	80	12	88
<b>1a</b>	<i>n</i> -butanol	80	6.0	48
<b>1a</b>	<i>n</i> -butanol	80	2.0	22
<b>1a</b>	<i>n</i> -butanol	100	12	85

<sup>a</sup>Esterification of **1a** (5 mmol, 1 equ.) with ethanol/*n*-butanol (12.5 mmol, 2.5 equ.) catalysed by potash alum (10 mol%) under different reaction temperature

<sup>b</sup>Isolated yield of ester after purification

a green solvent, we checked the conversion in acetonitrile (68%), but the optimum result (88%) was observed under solvent-free conditions only.

### 3.5 Esterification of formylphenoxyaliphatic acids with absolute ethanol

To extend the scope of the reaction as a general and practical procedure for esterification, we carried out the esterification of different formylphenoxyaliphatic acids with absolute ethanol at 80°C in the presence of potash alum (10 mol%) for 12 h. The results are presented in table 2.

### 3.6 Effect of chain length of alcohol on esterification of *o*-formylphenoxyacetic acid

The kinetics of esterification of *o*-formylphenoxyacetic acid with different alcohols (methanol, ethanol, *n*-butanol, *n*-hexanol) have been studied [see the [electronic supporting information](#) for details]. As the chain length of alcohol increases from methanol to *n*-hexanol, the rate of formation of ester is found to decrease.<sup>13</sup> This may be due to the fact that the larger molecules cannot penetrate into the bulk and can interact only on the surface of the catalyst.<sup>14</sup>

No side product was observed, and the corresponding ester was the exclusive product. In most of the cases, the esters obtained after the usual workup was pure and did not require additional purification, the excess of alcohol being evaporated under vacuum. Esterification with *n*-butanol and *n*-hexanol required separation through column chromatography (silica gel, *n*-hexane).

### 3.7 Effect of potash alum on esterification of Ibuprofen

Potash alum catalysed direct esterification of Ibuprofen with 2-propanol and *n*-butanol afforded the corresponding esters **3a** and **3b** in 72% and 78% yields, respectively (scheme 2) under the previously said conditions.

### 3.8 Catalyst recovery and reusability

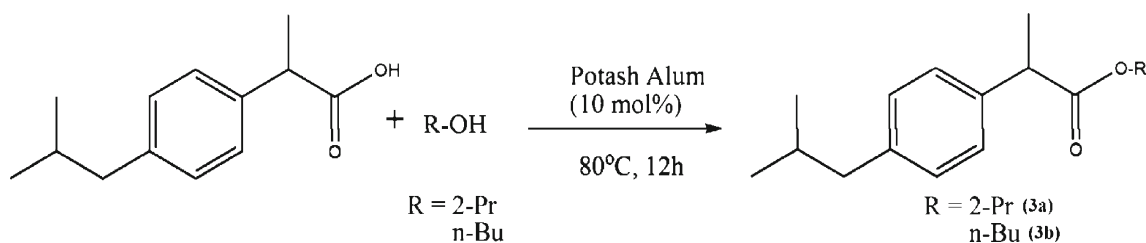
Our attention was then focused towards the possibility of catalyst-reusability which is highly preferable for greener processes. To demonstrate the catalyst-reuse, esterification of acid (**1a**) with *n*-butanol was performed at 80°C in the presence of potash alum under solvent-free conditions (5 mmol scale). After the completion of the reaction, the reaction mixture was filtered through a plug of cotton. The cotton plug was washed with ethyl

**Table 2.** Synthesis of different esters<sup>a</sup>.

Entry	Acids	Alcohols	Products	Isolated yield (%) <sup>b</sup>
1		Ethanol		92 ( <b>1a</b> )
2		Ethanol		92 ( <b>1b</b> )
3		Ethanol		94 ( <b>1c</b> )
4		Ethanol		95 ( <b>1d</b> )
5		Ethanol		96 ( <b>1e</b> )
6		Ethanol		96 ( <b>1f</b> )

<sup>a</sup>Esterification of acids (5 mmol) with alcohol (12.5 mmol) using potash alum (10 mol%) at 80°C

<sup>b</sup>Isolated yield of ester after purification



**Scheme 2.** Potash alum catalysed synthesis of prodrug of Ibuprofen.

acetate ( $3 \times 5$  mL) and the combined filtrates were concentrated to isolate the product. The cotton plug retaining the catalyst was transferred to a 25 mL round bottomed flask, washed with acetone (5 mL), and dried under vacuum ( $40^\circ\text{C}/22$  mm Hg) when the catalyst got separated out from the cotton. The recovered catalyst was dried under vacuum at  $60^\circ\text{C}$  for 12 h and reused for ten subsequent fresh batches of reactions which gave nearly the same yields as the first batch. This indicates zero catalytic loss in potash alum.

#### 4. Conclusion

In summary, we have described a new protocol for the esterification of formylphenoxyaliphatic acids using potash alum as heterogeneous acid catalyst. By modifying the reaction conditions, we were able to obtain the esters in good yield under mild conditions. Finally, the presented examples show that further enhancements in the esterification of aromatic/aliphatic acids with aromatic/aliphatic alcohols using potash alum may be discovered.

#### Electronic supplementary material

Electronic supplementary material contains detailed synthesis of acid and ester, and selected spectra (IR,  $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR and Mass) of esters, and details of other studies see in [www.ias.ac.in/chemsci](http://www.ias.ac.in/chemsci).

#### Acknowledgements

We wish to thank Dr. M Sankar, Cardiff Catalysis Institute, School of Chemistry, Cardiff University, Cardiff, UK for his assistance in the preparation of this manuscript. We also thank the Central Drug Research Institute (CDRI), Lucknow, India for mass analysis and Madurai Kamaraj University, Madurai, India for the NMR spectral data.

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