

## FeCl<sub>3</sub>·6H<sub>2</sub>O Catalyzed Reaction of Aromatic Aldehydes with 5, 5-Dimethyl-1, 3-cyclohexandione in Ionic Liquids

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**Abstract:** The reaction of aromatic aldehydes **1** with 5, 5-dimethyl-1, 3-cyclohexandione **2** was investigated in this paper by using [bmim][BF<sub>4</sub>] as the reaction medium. It was found that when the reaction was carried out in the presence of catalytic amount of FeCl<sub>3</sub>·6H<sub>2</sub>O, xanthenediones **3** was obtained in high yields. On the other hand, when a combination of trimethylchlorosilane (TMSCl) and FeCl<sub>3</sub>·6H<sub>2</sub>O was employed as the catalyst, the reaction afforded ring-opening derivatives of xanthenediones **4** with high efficiency.

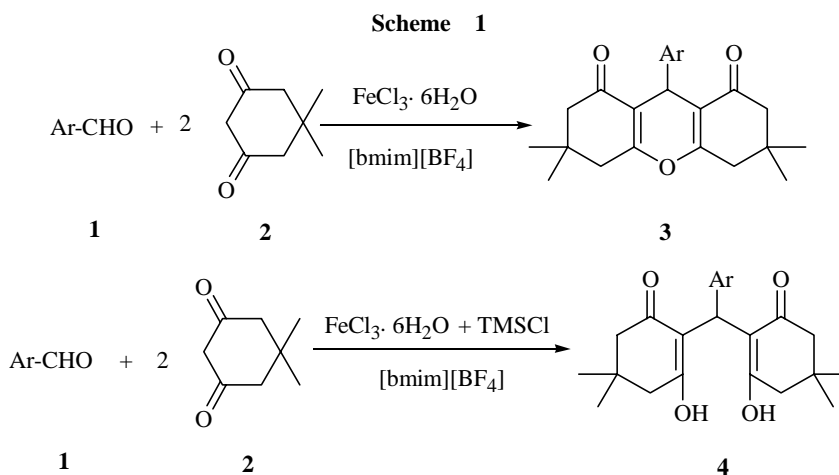
**Keywords:** FeCl<sub>3</sub>·6H<sub>2</sub>O, ionic liquids, xanthenedione, catalysis.

Room temperature ionic liquids with low melting point (<100°C) salts represent a new class of non-molecular, ionic solvents. Especially those based on the 1-N-alkyl-3-methylimidazolium cations, have shown great promise as an attractive alternative to conventional solvents for catalytic reactions<sup>1</sup>. On the other hand, FeCl<sub>3</sub>·6H<sub>2</sub>O was considered to be an environmentally benign Lewis acid and has been used successfully in several kinds of organic reactions<sup>2</sup>. Recently we have focused our interests on using a combination of FeCl<sub>3</sub>·6H<sub>2</sub>O and ionic liquids as novel green catalysis system in carbon-carbon forming reactions<sup>3</sup>. As a continuation of our research, we described here the interesting results of the reaction between aromatic aldehydes **1** and 5, 5-dimethyl-1, 3-cyclohexandione **2** in ionic liquid, 1-butyl-3-methylimidazolium tetrafluoroborate ([bmim][BF<sub>4</sub>]) by using FeCl<sub>3</sub>·6H<sub>2</sub>O alone or in combination of FeCl<sub>3</sub>·6H<sub>2</sub>O and TMSCl as catalyst respectively (**Scheme 1**). Through these reactions, a group of synthetically and biologically important compounds, namely xanthenediones **3** or their ring-opening derivatives **4** were obtained in high yields under mild reaction conditions.

It is well known that xanthenedione derivatives constitute a structural unit in a number of natural products<sup>4</sup> and have been used as versatile synthons due to the inherent reactivity of the inbuilt pyran ring<sup>5</sup>. Conventional synthesis of xanthenediones usually involves acid or base catalyzed condensation of appropriate active methylene carbonyl compounds with aldehydes<sup>6</sup>. Recently, several reports have been put forward in which xanthenedione derivatives were obtained through condensation of aldehyde and 5, 5-di-

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methyl-1, 3-cyclohexanedione under various conditions<sup>7</sup>. These processes offered lots of novel alternatives for the preparation of xanthenediones, but they still have to be further improved in terms of the yield, reaction time, practicability and the limitation of the instrument necessitated in corresponding procedures. Therefore, developing novel and practical methods for the preparation of xanthenedione and its derivatives is still necessary.

In a general procedure, **1** (0.50 mmol) and **2** (1.00 mmol) were added to 1 mL [bmim][BF<sub>4</sub>] containing 0.10 mmol FeCl<sub>3</sub>·6H<sub>2</sub>O in a 10 mL round-bottomed flask. Then the mixture was stirred at 80°C for a certain period of time to complete the reaction (monitored by TLC). At completion, water was added to the reaction mixture and the solid was collected by suction and subsequently rinsed with cold ethanol to give product **3** with high purity. The results were shown in **Table 1**.

In our further efforts to reduce the amount of FeCl<sub>3</sub>·6H<sub>2</sub>O without impairing the selectivity and yield of the above reaction, 0.50 mmol TMSCl was tried as a co-catalyst along with 0.05 mmol FeCl<sub>3</sub>·6H<sub>2</sub>O to catalyze the reaction of **1** and **2**. To our surprise, after the mixture being treated under similar reaction conditions as described above, it gave **4** in high yield instead of **3** (**Table 2**). Further study showed that while 0.50 mmol TMSCl alone can also serve as an effective catalyst for the preparation of **4**, but the presence of FeCl<sub>3</sub>·6H<sub>2</sub>O can remarkably reduce the reaction time (**Table 2**, entries 1 and 2).

All the products in **Table 1** and **Table 2** were fully characterized by <sup>1</sup>H NMR, IR, MS and by comparison with authentic samples. Finally, it should be noted that in both procedures, [bmim][BF<sub>4</sub>] together with the catalyst used could be recovered easily and reused for at least 5 times without any loss of the activity.

In conclusion, we have provided a novel green procedure for the preparation of xanthenediones and their ring-opening derivatives. The main advantages of this method include high yields, simple experimental procedure, ease of recovering and reusing of the catalyst and the reaction media, as well as green and environmentally benign properties.

**Table 1** Preparation of **3** catalyzed by FeCl<sub>3</sub>·6H<sub>2</sub>O in [bmim][BF<sub>4</sub>] at 80 °C

Product	Ar	Reaction time (h)	Isolated yield (%)	M. p. (lit.) (°C)
<b>3a</b>	<i>m</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	6	90	145 - 148
<b>3b</b>	C <sub>6</sub> H <sub>5</sub>	6	92	203 - 205 (198 - 200) <sup>7b</sup>
<b>3c</b>	<i>p</i> -CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	6	93	205 - 207 (218 - 220) <sup>7b</sup>
<b>3d</b>	<i>p</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	6	95	226 - 228 (222 - 224) <sup>7b</sup>
<b>3e</b>	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	7	93	230 - 233 (230 - 231) <sup>7b</sup>
<b>3f</b>	<i>p</i> -BrC <sub>6</sub> H <sub>4</sub>	6	91	236 - 238
<b>3g</b>	<i>p</i> -FC <sub>6</sub> H <sub>4</sub>	5	95	225 - 228 (225 - 227) <sup>7c</sup>
<b>3h</b>	<i>o</i> -ClC <sub>6</sub> H <sub>4</sub>	6	87	224 - 226 (228 - 229) <sup>7c</sup>
<b>3i</b>	<i>o</i> -BrC <sub>6</sub> H <sub>4</sub>	6	85	220 - 222

**Table 2** Preparation of **4** under the catalysis of TMSCl/FeCl<sub>3</sub>·6H<sub>2</sub>O in [bmim][BF<sub>4</sub>] at 80 °C

Product	Ar	Reaction time (h)	Isolated yield (%)	M. p. (lit.) (°C)
<b>4a</b>	<i>m</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	12	87 <sup>a</sup>	193 - 195
<b>4a</b>	<i>m</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	4	91	193 - 195
<b>4b</b>	C <sub>6</sub> H <sub>5</sub>	6	89	186 - 188 (186 - 189) <sup>8</sup>
<b>4c</b>	<i>p</i> -CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	6	85	125 - 128 (128 - 130) <sup>8</sup>
<b>4d</b>	<i>p</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	4	93	185 - 187 (182 - 183) <sup>8</sup>
<b>4e</b>	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	6	90	138 - 141 (134 - 135) <sup>8</sup>
<b>4f</b>	<i>p</i> -BrC <sub>6</sub> H <sub>4</sub>	5	87	172 - 174
<b>4g</b>	<i>p</i> -FC <sub>6</sub> H <sub>4</sub>	5	92	184 - 186 (187 - 189) <sup>7c</sup>
<b>4h</b>	<i>o</i> -ClC <sub>6</sub> H <sub>4</sub>	6	81	199 - 201 (198 - 200) <sup>8</sup>
<b>4i</b>	<i>o</i> -BrC <sub>6</sub> H <sub>4</sub>	6	80	200 - 202

<sup>a</sup>yield obtained under the catalysis of TMSCl alone.

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