

## Microwave-promoted rapid and efficient method for acetylation of phenols with acetic anhydride using NaF as catalyst under solvent-free conditions

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### ABSTRACT

Sodium fluoride is found to efficiently catalyse the acetylation of phenols with acetic anhydride in excellent yields in solvent-free conditions under microwave irradiation.

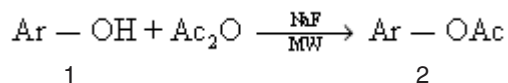
**Key words:** Acetylation, phenol, acetic anhydride, sodium fluoride, solvent-free condition, microwave irradiation.

### INTRODUCTION

The protection of hydroxyl group of phenols by the formation of esters is of great importance in synthetic organic chemistry<sup>1</sup>. In addition, some esters have particular fragrant which applied as raw materials for production of perfumery. The routine acylation of phenols is carried out by acid anhydrides or acid chlorides in the presence of tertiary amines such as triethylamine and pyridine<sup>2</sup>. In addition to these catalysts, protonic acids such as conc. H<sub>2</sub>SO<sub>4</sub><sup>3</sup>, Lewis acids such as ZnCl<sub>2</sub><sup>4</sup>, and cobalt polyoxometalate<sup>5</sup> were also applied to catalyze the acylation of phenols. Each of the above methods has its merit and some short coming. Some of these methods were not satisfactory because of low yields, long reaction time, problems of corrosivity, tedious workup, effluent treatment and difficulties in isolation of products. For example, triethylamine and pyridine have unpleasant odour and not so easy to remove. Consequently, there is need to develop an alternative methods for the acetylation of phenols under mild and environmentally friendly conditions. More recently, montmorillonite K-10 and KSF<sup>6</sup>,

expansive graphite<sup>7</sup> and zeolites<sup>8</sup> were applied as solid catalysts for this purpose to obtain relatively better yields.

The application of microwave (MW) irradiation in organic synthesis has been the focus of considerable attention in recent years and is becoming an increasingly popular technology<sup>9</sup>. The salient features of the microwave approach are the rapid reaction rates, cleaner reaction conditions and ease of manipulation. In view of this, herein we wish to report a rapid and efficient method for the acetylation of phenols catalyzed by NaF under microwave irradiation (Scheme 1). NaF has been chosen as the reagent of choice because of its ready availability and low cost.



As summarized in Table 2 when phenols 1 were treated with acetic anhydride in the presence of NaF under microwave irradiation the

corresponding aryl acetates 2 were obtained in excellent yields. The reaction proceeds efficiently at ambient pressure within a few minutes. Polyhydroxyl compounds were converted into the corresponding polyacetates (entries 6,7). This method tolerates other functionalities such as nitro, halides, ketones and carboxylic acid groups. Further, it is to be noted that highly pure products were obtained using this simple procedure and in most cases no further purification was needed. The high yields of the acetates in so short time certainly manifest the advantages and potentialities of microwave oven as source of energy in organic synthesis. By conventional heating method (oil bath) at 120°C, the reaction was still incomplete after 24 hours.

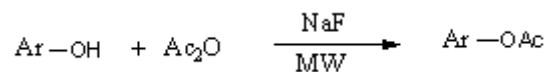
The compounds were characterized by IR and <sup>1</sup>H NMR spectral data (Table 1) and finally by comparison with authentic samples<sup>10</sup>.

To the best of our knowledge, this is the first report of acetylation of phenols with acetic anhydride using NaF as catalyst under microwave irradiation.

In conclusion, we have developed a rapid and highly efficient method for the acetylation of phenols with acetic anhydride using NaF as catalyst under microwave irradiation. This method is superior in terms of operational simplicity, economic viability, short reaction times and high yields of the products to the reported methods.

## EXPERIMENTAL

Melting points were determined using



Scheme 1

Table 1: IR and <sup>1</sup>H NMR spectral data of aryl acetates 2

| Entry | Product | IR (KBr)<br>vmax in cm-1 | <sup>1</sup> H NMR (200 MHz, CDCl <sub>3</sub> )<br>(δppm)   |
|-------|---------|--------------------------|--|
| 2a    |         | 1758, 1686,<br>1601      | 2.30 (s, 3H, COCH <sub>3</sub> ), 2.52 (s, 3H, OCOCH <sub>3</sub> ), 7.08 (d, 1H, Ar-H), 7.30 (m, 1H, Ar-H), 7.52 (m, 1H, Ar-H), 7.80 (d, 1H, Ar-H).   |
| 2b    |         | 1758, 1684, 1600         | 2.30 (s, 3H, COCH <sub>3</sub> ), 2.50 (s, 3H, OCOCH <sub>3</sub> ), 7.18 (d, 2H, Ar-H), 7.98 (m, 2H, Ar-H).   |
| 2f    |         | 1766, 1600               | 2.23 (s, 6H, 2 x CH <sub>3</sub> ), 7.02 (m, 4H, Ar-H)   |
| 2i    |         | 1752, 1599               | 4.02 (s, 3H, CH <sub>3</sub> ), 7.02-7.78 (m, 7H, Ar-H)  |
| 2k    |         | 1758, 1601               | 2.15 (s, 3H, CH <sub>3</sub> ), 8.10 (m, 2H, C <sub>3</sub> -H, C <sub>4</sub> -H), 8.75 (m, 1H, C <sub>2</sub> -H), 7.10-7.45 (m, 3H, C <sub>5</sub> -H, C <sub>6</sub> -H, C <sub>7</sub> -H). |
| 2l    |         | 1756, 1720, 1600         | 2.35 (s, 3H, CH <sub>3</sub> ), 2.48 (s, 3H, OCOCH <sub>3</sub> ), 6.25 (s, 1H, C3-H), 7.05 (m, 2H, C <sub>6</sub> -H, C8-H), 7.60 (d, 1H, C <sub>5</sub> -H).                                   |

**Table 2: Acetylation of phenols with Ac<sub>2</sub>O in the presence of NaF under microwave irradiation**

| Entry | Substrate | Product | Reaction time (min) | Yield (%) | m.P. (°C)<br>(Lit. mp <sup>10</sup> ) |
|-------|-----------|---------|---------------------|-----------|---------------------------------------|
| 2a    |           |         | 3.0                 | 97        | 90<br>(90-91)                         |
| 2b    |           |         | 2.5                 | 98        | 52-54<br>(52-55)                      |
| 2c    |           |         | 2.5                 | 96        | 192-94<br>(191-94)                    |
| 2d    |           |         | 2.0                 | 96        | 55<br>(55-66)                         |
| 2e    |           |         | 1.5                 | 98        | 82<br>(81-82)                         |
| 2f    |           |         | 2.0                 | 98        | 122-23<br>(123)                       |
| 2g    |           |         | 3.0                 | 96        | 104-105<br>(104)                      |
| 2h    |           |         | 1.5                 | 96        | 86-87<br><br>(87)                     |
| 2i    |           |         | 2.0                 | 98        | 69-70<br><br>(70)                     |
| 2j    |           |         | 2.0                 | 97        | 47<br><br>(47-48)                     |
| 2k    |           |         | 2.5                 | 98        | 56<br>(56-57)                         |
| 2l    |           |         | 2.0                 | 98        | 152-155<br>(153-155)                  |

Cintex melting point apparatus and are uncorrected. Purity of compounds was checked using precoated TLC plates (Merk, 60F-254). IR spectra (KBr) ( $\nu_{\max}$ ;  $\text{cm}^{-1}$ ) were recorded on a Perkin-Elmer BX series FT-IR spectrophotometer and  $^1\text{H}$  NMR spectra on a Varian Gemini 200 MHz spectrometer (Chemical shifts in  $\delta$  ppm) using TMS as internal standard. For microwave irradiation LG MG 556 P (2450 MHz) domestic microwave oven was used.

#### General procedure for acetylation of phenols

A mixture of phenol **1** (0.1 mol), acetic anhydride (2 equivalents to each hydroxyl group in the phenol) and NaF (0.420 gm) was subjected to

microwave irradiation at 400 W for the specified time as indicated in Table 2. After completion of the reaction as indicated by TLC, the reactions mixture was allowed to attain room temperature and poured onto crushed ice. The solid thus obtained was filtered, washed with ice cold water and recrystallized from ethanol to give pure aryl acetates **2** (Table 2).

#### ACKNOWLEDGEMENTS

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