

## Note

### Microwave-enhanced Knoevenagel condensation catalysed by $\text{NH}_2\text{SO}_3\text{NH}_4$

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Ammonium sulphamate catalyses the efficient Knoevenagel condensation of aromatic aldehydes **1** with active methylene compounds in solvent-free conditions under microwave irradiation to give arylidene derivatives **3**. The yields are excellent and purity is high. The method is preoperatively convenient and useful.

**Keywords:** Knoevenagel condensation, aromatic aldehydes, active methylene compounds,  $\text{NH}_2\text{SO}_3\text{NH}_4$ , solvent-free conditions, microwave irradiation

Knoevenagel reaction is an important name reaction by which the alkenes are obtained from carbonyl compounds and active methylene compounds in the presence of a basic catalyst or Lewis acid catalyst<sup>1</sup>.

Recently, the use of inorganic solids as catalysts is rapidly increasing, because of these reactions often involve milder reaction conditions, easier work-up and higher selectivity than similar homogenous reaction<sup>2</sup>. Consequently, the environmentally friendly solid bases such as  $\text{AlPO}_4\text{-Al}_2\text{O}_3$  (ref. 3), alkylamine-functionalized silicagel<sup>4</sup>, ZnO or MgO (ref. 5), xonolite (ref. 6),  $\text{KF/Al}_2\text{O}_3$  (ref. 7), aluminophosphate oxynitride<sup>8</sup>, aminopropyl-functionalized MCMs (Ref. 9), MCM-41 supported binary caesium-lanthanum oxide<sup>10</sup>, zirconophosphate oxynitride<sup>11</sup>, modified Mg-Al hydrotalcite<sup>12</sup>, zeolite CSX (ref. 13), alkaline and alkaline earth carbonates<sup>14</sup>, diamino-cuntionalized MCM-41 (ref. 15), calcined Mg-Al hydrotalcite (Ref. 16), barium dimethyl amino-ethyl phosphate (ref. 17) and zirconium dimethylaminoethylphosphonate-phosphate (ref. 18) etc. have been employed in Knoevenagel condensation. However, no attention has been paid to the use of readily available and cheaper salt such as  $\text{NH}_2\text{SO}_3\text{NH}_4$  as catalyst.

During the post two decades, considerable attention has been focused on the application of microwave in

organic synthesis, and a handful of papers in this field were reported<sup>19-21</sup>.

In view of this and in continuation of our interest on microwave assisted organic transformations<sup>22-25</sup> we describe here a rapid and simple procedure for microwave-assisted Knoevenagel condensation. Various aromatic aldehydes react with active methylene compounds (malononitrile ethyl cyanoacetate and cyanoacetamide) catalyzed by ammonium sulphamate ( $\text{NH}_2\text{SO}_3\text{NH}_4$ ) under solvent-free microwave irradiation conditions (**Scheme I**). The reactions proceeded smoothly under reaction conditions and gave desired products in excellent yields and no Michael product was observed. The reaction did not proceed at all when performed without  $\text{NH}_2\text{SO}_3\text{NH}_4$ .

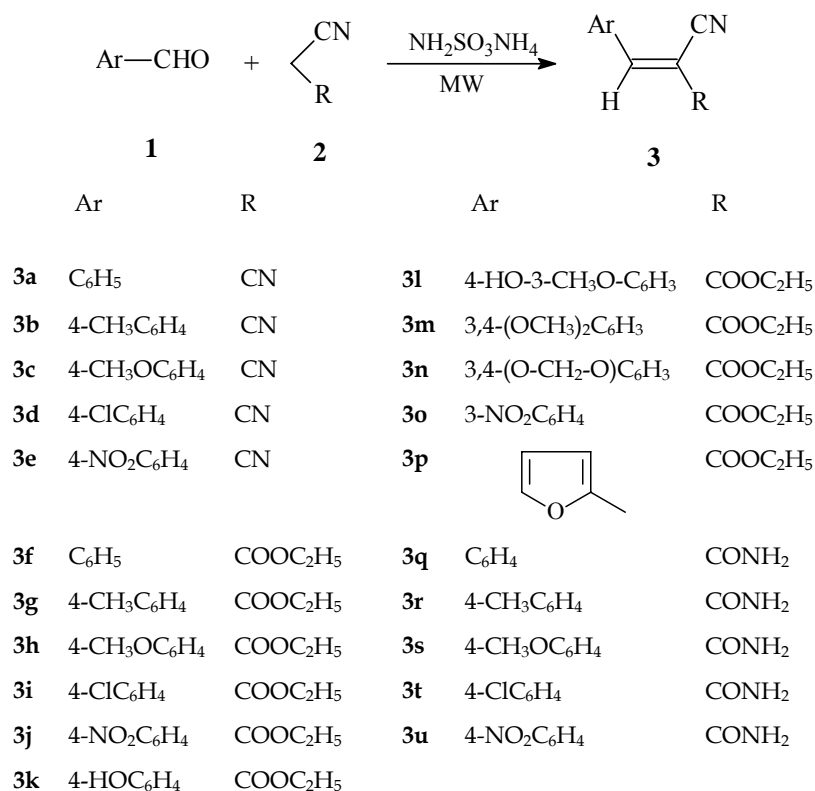
The generality of this approach has been demonstrated by the condensation of a wide variety of aromatic aldehydes (bearing electron withdrawing and electron-releasing groups) with active methylene compounds (**Table I**). It was found that in all cases high yield of product is formed.

Our results show that  $\text{NH}_2\text{SO}_3\text{NH}_4$  is an efficient, in-expensive, non-toxic, stable and easily available catalyst for Knoevenagel reaction and that microwave irradiation greatly enhances the reaction. In comparing the rate enhancement effect of microwave irradiation on the investigated reaction, the condensation between benzaldehyde and malononitrile was chosen as a model reaction. In similar experimental conditions with the same amount of starting materials and  $\text{NH}_2\text{SO}_3\text{NH}_4$ , conventional heating needed a 1.5 hr to give the expected product in similar yield (92%). It can manifest the advantage and potentiality of microwave as a source of energy in Knoevenagel reactions.

To the best of our knowledge, this is the first example for  $\text{NH}_2\text{SO}_3\text{NH}_4$  catalysis of this reaction.

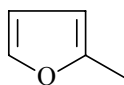
In conclusion, our results confirm that the  $\text{NH}_2\text{SO}_3\text{NH}_4$  is an efficient catalyst for the microwave assisted Knoevenagel reaction in terms of excellent yields, short reaction times, facile work-up, and economically viable reagent. The method is environmentally benign.

All the compounds **3** prepared were characterized by spectral (IR and <sup>1</sup>H NMR) data (**Table II**) and finally by comparison with authentic samples (Ref. 26-31).



Scheme I

**Table I** — Microwave-enhanced Knoevenagel condensation of aromatic aldehydes **1** with active methylene compounds **2** in the presence of NH<sub>2</sub>SO<sub>3</sub>NH<sub>4</sub> under solvent-free conditions.

Compd	Ar	R	Reaction time (sec)	Yield (%)	m.p. °C
<b>3a</b>	C <sub>6</sub> H <sub>5</sub>	CN	10	98	87-88
<b>3b</b>	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	CN	10	99	129-30
<b>3c</b>	4-CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub>	CN	10	96	115-16
<b>3d</b>	4-ClC <sub>6</sub> H <sub>4</sub>	CN	8	98	162-63
<b>3e</b>	4-NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	CN	8	95	159-60
<b>3f</b>	C <sub>6</sub> H <sub>5</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	96	49-50
<b>3g</b>	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	8	98	90-91
<b>3h</b>	4-CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	95	89-90
<b>3i</b>	4-ClC <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	5	98	92-93
<b>3j</b>	4-NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	96	169-70
<b>3k</b>	4-HOC <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	95	172
<b>3l</b>	4-HO-3-CH <sub>3</sub> O-C <sub>6</sub> H <sub>3</sub>	COOC <sub>2</sub> H <sub>5</sub>	15	96	100
<b>3m</b>	3,4-(OCH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>3</sub>	COOC <sub>2</sub> H <sub>5</sub>	15	97	157
<b>3n</b>	3,4-(O-CH <sub>2</sub> -O)C <sub>6</sub> H <sub>3</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	96	96
<b>3o</b>	<i>m</i> -NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	COOC <sub>2</sub> H <sub>5</sub>	10	95	130
<b>3p</b>		COOC <sub>2</sub> H <sub>5</sub>	10	97	95
<b>3q</b>	C <sub>6</sub> H <sub>5</sub>	CONH <sub>2</sub>	15	96	124-25
<b>3r</b>	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	CONH <sub>2</sub>	20	98	161-62
<b>3s</b>	4-CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub>	CONH <sub>2</sub>	15	92	214-15
<b>3t</b>	4-ClC <sub>6</sub> H <sub>4</sub>	CONH <sub>2</sub>	10	98	210-11
<b>3u</b>	4-NO <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	CONH <sub>2</sub>	10	97	237-38

**Table II** — IR and  $^1\text{H}$  NMR spectral data of olefinic arylidene derivatives **3**

Compd	IR (KBr, $\text{cm}^{-1}$ )	$^1\text{H}$ NMR (200 MHz, $\text{CDCl}_3$ , $\delta$ , ppm)
<b>3a</b>	2224, 1591	7.58 (m, 3H), 7.73 (s, 1H, =CH), 7.90 (d, 2H, $J = 8.5$ Hz).
<b>3b</b>	2223, 1589,	2.48 (s, 3H, $\text{CH}_3$ ), 7.32 (d, 2H, $J = 8.4$ Hz), 7.68 (s, 1H, =CH), 7.83 (d, 2H, $J = 8.4$ Hz).
<b>3c</b>	2223, 1607	3.91 (s, 3H, $\text{OCH}_3$ ), 7.00 (d, 2H, $J = 8.9$ Hz), 7.62 (s, 1H, =CH), 7.92 (d, 2H, $J = 8.9$ Hz).
<b>3d</b>	2229, 1584	7.51 (d, 2H, $J = 8.5$ Hz), 7.70 (s, 1H, =CH), 7.85 (d, 2H, $J = 8.5$ Hz).
<b>3e</b>	2231, 1607	8.12 (d, 2H, $J = 8.8$ Hz), 8.31 (d, 2H, $J = 8.8$ Hz), 8.50 (s, 1H, =CH).
<b>3f</b>	2216, 1725, 1596	1.45 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.40 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 7.52 (m, 3H), 7.98 (d, 2H, $J = 8.4$ Hz), 8.22 (s, 1H, =CH).
<b>3g</b>	2216, 1726, 1598	1.41 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 2.42 (s, 3H, $\text{CH}_3$ ), 4.36 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 7.28 (d, 2H, $J = 8.4$ Hz), 7.89 (d, 2H, $J = 8.4$ Hz), 8.19 (s, 1H, =CH).
<b>3h</b>	2215, 1718, 1585	1.40 (t, 3H, $J = 7.2$ Hz, $\text{OCH}_2\text{CH}_3$ ), 3.89 (s, 3H, $\text{OCH}_3$ ), 4.35 (q, 2H, $J = 7.2$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.98 (d, 2H, $J = 8.9$ Hz), 7.97 (d, 2H, $J = 8.9$ Hz), 8.10 (s, 1H, =CH).
<b>3i</b>	2224, 1725, 1614	1.42 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.38 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 7.46 (d, 2H, $J = 8.5$ Hz), 7.94 (d, 2H, $J = 8.5$ Hz), 8.21 (s, 1H, =CH).
<b>3j</b>	2225, 1723, 1616	1.44 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.42 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 8.21 (d, 2H, $J = 8.7$ Hz), 8.42 (d, 2H, $J = 8.7$ Hz), 8.36 (s, 1H, =CH).
<b>3k</b>	3296, 2231, 1716, 1590	1.40 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.35 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.62 (br, s, 1H, OH), 6.97 (d, 2H, $J = 8.7$ Hz), 7.90 (d, 2H, $J = 8.7$ Hz), 8.22 (s, 1H, =CH).
<b>3l</b>	3379, 2223, 1704, 1576	1.35 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 3.95 (s, 3H, $\text{OCH}_3$ ), 4.35 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.25 (br, s, 1H, OH), 6.98 (d, 1H, $J = 8.3$ Hz), 7.40 (d, 1H, $J = 8.3$ Hz), 7.85 (s, 1H), 8.15 (s, 1H, =CH).
<b>3m</b>	2224, 1715, 1591	1.45 (t, 3H, $J = 7.2$ Hz, $\text{OCH}_2\text{CH}_3$ ), 3.94 (s, 6H, 2 x $\text{OCH}_3$ ), 4.40 (q, 2H, $J = 7.2$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.93 (d, 1H, $J = 8.4$ Hz), 7.50 (d, 1H, $J = 8.4$ Hz), 7.83 (s, 1H), 8.15 (s, 1H, =CH).
<b>3n</b>	2223, 1730, 1590	1.42 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.39 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.09 (s, 2H, $\text{OCH}_2\text{O}$ ), 6.19 (d, 1H, $J = 8.1$ Hz), 7.42 (d, 1H, $J = 8.1$ Hz), 7.71 (s, 1H), 8.10 (s, 1H, =CH).
<b>3o</b>	2216, 1720, 1607	1.45 (t, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.43 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 7.75 (t, 1H, $J = 8.1$ Hz), 8.31 (s, 1H, =CH), 8.42 (d, 2H, $J = 8.1$ Hz), 8.71 (s, 1H).
<b>3p</b>	2223, 1716, 1621	1.40 (s, 3H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 4.35 (q, 2H, $J = 7.1$ Hz, $\text{OCH}_2\text{CH}_3$ ), 6.65 (m, 1H, 4'-H), 7.38 (d, 1H, $J = 3.6$ Hz, 3'-H), 7.74 (d, 1H, $J = 1.8$ Hz, 5'-H), 8.02 (s, 1H, =CH).
<b>3q</b>	3400, 3163, 2217, 1693, 1598	6.20 (br, s, 2H, $\text{NH}_2$ ), 7.50 (m, 3H), 7.95 (d, 2H, $J = 8.5$ Hz), 8.38 (s, 1H, =CH).
<b>3r</b>	3391, 3159, 2220, 1695, 1592	2.45 (s, 3H, $\text{CH}_3$ ), 6.31 (br, s, 2H, $\text{NH}_2$ ), 7.31 (d, 2H, $J = 8.4$ Hz), 7.85 (d, 2H, $J = 8.4$ Hz), 8.30 (s, 1H, =CH).
<b>3s</b>	3448, 3174, 2208, 1699, 1584	3.92 (s, 3H, $\text{OCH}_3$ ), 7.00 (d, 2H, $J = 8.9$ Hz), 7.25 (br, s, 2H, $\text{NH}_2$ ), 7.98 (d, 2H, $J = 8.9$ Hz), 8.22 (s, 1H, =CH).
<b>3t</b>	3456, 3155, 2214, 1704, 1585	7.25 (br, s, 2H, $\text{NH}_2$ ), 7.52 (d, 2H, $J = 8.5$ Hz), 7.92 (d, 2H, $J = 8.5$ Hz), 8.20 (s, 1H, =CH).
<b>3u</b>	3439, 3346, 2218, 1694, 1595	7.40 (br, s, 2H, $\text{NH}_2$ ), 8.12 (d, 2H, $J = 8.8$ Hz), 8.31 (d, 2H, $J = 8.8$ Hz), 8.40 (s, 1H, =CH).

### Experimental Section

All melting points were determined on a Cintex melting point apparatus and are uncorrected. The purity of the compounds was checked by TLC. IR spectra (KBr) 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  $\delta$ ,) using TMS as internal standard. The reactions were carried out in LG MS 556P, 2450 MHz domestic microwave oven.

**General Procedure.** A mixture of appropriate aromatic aldehyde **1** (0.01 mole) active methylene

compound **2** (0.01 mole) and  $\text{NH}_2\text{SO}_3\text{NH}_4$  (0.01 mole) was subjected to microwave irradiation at 400 watts intermittently at 5 sec intervals for specified time (**Table I**). After completion of the reaction as indicated by TLC, the reaction-mixture was cooled to RT and treated with crushed ice. The solid thus obtained was filtered, dried and recrystallized from ethanol to give **3** (**Table I**).

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