

## A Facile and Efficient Green Protocol for the Knoevenagel Condensation in Aqueous Media

J.P.SONAWANE, S.B.CHAUDHARI, S.S.PATIL, M.V.SONAWANE

Department of Chemistry, R.C.Patel ACS College, Shirpur, Dist-Dhule, (M.S.) 425405,  
Corresponding author: jaysonawane5@gmail.com

### Abstract

*An easy and efficient method has been developed to carry out Knoevenagel condensation reaction via the reaction of various aromatic aldehydes with Malononitrile by using catalytic amount of Ni (NO<sub>3</sub>)<sub>2</sub> .6H<sub>2</sub>O at room temperature in aqueous media. Some advantages of this protocol are its very good yields, easily available catalysts, simple workup procedure, and short reaction times.*

**Key Words:** Aldehyde, Malononitrile, Knoevenagel condensation, Catalyst, Water.

### Introduction

The challenges in organic synthesis are to develop convenient processes, reaction media, conditions and utility of materials based on the design of green chemistry is one of the important issues in the chemical society<sup>1</sup>. In recent strong synthetic effort are done to use of approaches that are beneficial to industry as well as to the environment. Since Green Chemistry is primarily concerned with the reduction of chemical hazards and pollution<sup>2</sup>. Thus, the use of aqueous solvents in chemical reactions has proved a cleaner and safer substitute to organic solvents<sup>3</sup>.

Knoevenagel condensation of aromatic aldehyde with active methylene compounds has been broadly used in view of its significance in carbon-carbon bond formation.<sup>4</sup> Different catalysts have been used to carry out this reaction. Strong bases such as amines, alkali alkoxides, alkali hydroxide, pyridine, piperidine and ammonium salts catalyze the reaction in presence of organic solvents.<sup>5-7</sup> Widely the Knoevenagel condensation is catalyzed by Lewis bases and acids including ZnCl<sub>2</sub><sup>8</sup>, CdI<sub>2</sub>, TiCl<sub>4</sub><sup>9</sup>, Al<sub>2</sub>O<sub>3</sub><sup>10</sup>, MgO<sup>11</sup>, ZnO<sup>12</sup>. However, this requires harmful solvent, prolonged heating and reflux conditions.

The use of such chemicals and solvents has led to environmental problems, i.e. the necessity to dispose huge amount of organic waste due to the formation of undesirable side products. There are some also reported methods uses catalysts like zeolites<sup>13</sup>, iodine<sup>14</sup>, lithium hydroxide<sup>15</sup>, FeSO<sub>4</sub><sup>16</sup>, ammonium sulphate<sup>17</sup>, triethylamine<sup>18</sup> and ionic liquids<sup>19</sup>.

From above literature survey, it was cleared that many work on knoevenagel reaction was going on. But each work is only concerns with conventional methods. But very few reports were fascinated on synthesis of carbon carbon double bond by green approach. The methodologies reported above have some disadvantages such as prolonged reaction time, the high reaction temperatures, an excess of costly dehydrating reagents/catalysts, moisture sensitive catalysts, and special apparatus, etc. Considering these facts, we have decided to synthesize knoevenagel products of various substituted aldehydes and malanonitrile by employing transition metal nitrates as green catalyst for green approach. Also the use of water as solvent, the most environmentally benign of all solvents, offers a very useful green methodology from both

the economical and synthetic points of view.<sup>20-23</sup>. Therefore in the present work, some products were prepared with help of green protocol.

The aim of this research was to monitor simple and economic methods for preparation of Knoevenagel products. Here in Ni (NO<sub>3</sub>)<sub>2</sub>.6H<sub>2</sub>O promoted condensation reaction of substituted aldehydes and malononitrile displayed the

appropriate practicing way for forming a series of products. Synthesis of condensed products are often carried out with acid-catalyzed and generally by refluxing the mixture of aldehydes and malononitrile in organic medium. However, with the assistance of Ni (NO<sub>3</sub>)<sub>2</sub>.6H<sub>2</sub>O, it was found that the condensation reaction could proceed fast and efficiently (Table 1).

**Table 1.** Chemical compositions of (C<sub>6</sub>H<sub>5</sub>N)<sub>x</sub> V<sub>2</sub>O<sub>5</sub>.nH<sub>2</sub>O and value of *x* and *n*, calculated from CHN data.

Sample	C(%)	H(%)	N(%)	x	n
S1	-	1.83	-	-	1.97
S2	19.03	1.42	3.12	0.64	0.11
S3	22.01	1.59	4.09	0.77	0.06

### Materials and Methods-

All chemicals used were purchased from S. D. Fine chemicals. Melting points were determined using in open capillary tubes and are uncorrected. IR spectra were performed on a Galaxy series FTIR 5000 spectrometer using KBr discs. NMR spectra were recorded on a Bruker (300 MHz) spectrometer. Chemical shifts (ppm) were referenced to the internal standard tetramethylsilane (TMS). Reactions were monitored by thin layer chromatography (TLC) precoated silica gel plates (60F<sub>254</sub> 0.2mm layer E.Merck).

### Experimental Section-

#### General Procedure-

To a solution of Malononitrile (1 mmol) and corresponding aromatic aldehyde (1 mmol) 5 mol % Ni (NO<sub>3</sub>)<sub>2</sub> .6H<sub>2</sub>O in water was added and the reaction mixture stirred at room temperature for the desired time till the completion of reaction checked by TLC. After completion of the reaction, cold water (15-25 mL) was added to give the product. The solid was filtered and washed with cold water and air dried.

### Results and discussion

Knoevenagel condensation is basically reported as base catalysed reaction. In literature we found both acid as well as base catalysts reported efficiently for this condensation<sup>24</sup>. As a part of our research work, we have reported the Knoevenagel condensation using commercial catalyst in water.

At first we required a mild and suitable method for the mixture of Malononitrile and substituted benzaldehydes at room temperature. For optimization of the amount of catalyst, the reaction of malononitrile with substituted benzaldehydes at ambient temperature was carried out as a mock-up reaction and different amounts of catalyst were tested under the same conditions. The use of 5 mol% of Ni (NO<sub>3</sub>)<sub>2</sub> .6H<sub>2</sub>O in water for 10 min afforded the corresponding product in 90% yield (Table 2, entry 1). The results are summarized in Table 2. The yield of reaction in the presence of 5 mol% of Ni (NO<sub>3</sub>)<sub>2</sub> .6H<sub>2</sub>O and using water as a solvent was increased up to 98%.

Also, using water as the reaction medium made the separation method much easier than other solvents i.e. with water as a solvent, the

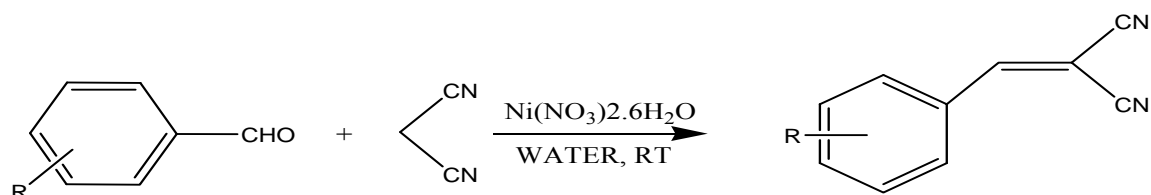
product could be obtained with high purity through simple filtration and washing with a little amount of water and a very small quantity of catalyst is sufficient for completion of reaction and for getting better yields.

To study the advance development of this method, this procedure was extended for preparation of other products. The reaction was

carried out at room temperature by taking a 1:1 mol ratio mixture of Malononitrile **1** and the corresponding aromatic aldehyde **2** in the presence of 5 mol% of  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  in methanol to give respective adducts **3A-K** (Scheme I). The results are summarized in Table 2.

**Table 2.** Condensation reaction of Malononitrile with aromatic aldehydes in the presence of 5 mol% of  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  at room temperature

Compound	Aldehyde	Time (min)	Melting Point °C Observed	Melting Point °C Reported	Yield %
3A	Benzaldehyde	10	80	82-84	90
3B	4- Bromo Benzaldehyde	15	154	153-155	90
3C	2- Chloro Benzaldehyde	20	92	95-96	96
3D	4- Nitro Benzaldehyde	20	102	103-105	98
3E	4- Chloro Benzaldehyde	20	156	159-161	92
3F	4- Methoxy Benzaldehyde	30	118	115-118	90
3G	4- Fluoro Benzaldehyde	10	126	127-129	96
3H	4- Hydroxy Benzaldehyde	40	190	187-189	80
3I	2- Hydroxy Benzaldehyde	30	156	160-162	85
3J	Furan 2-Carboxyaldehyde	30	70	71-73	89
3K	Thiopene-2-carboxyaldehyde	25	90	90-92	93



SCHEME- I

**Spectral data of compound (3A) IR (KBr  $\text{cm}^{-1}$ )** - 1500, 1645, 3034, 2220,  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ) –  $\delta$  7.30 (dd, 1H CH), 7.39 (m 1H CH), 7.33 (m 1H, CH), 7.93 (d, 1H CH).  $^{13}\text{C}$  ( $\text{CDCl}_3$ ):- 126.4, 128.7, 128.0, 135.2, 156.2, 69.2, 113.6.

**Spectral data of compound (3D) IR (KBr  $\text{cm}^{-1}$ )** -1537, 1625, 3030, 2260, 987.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ) –  $\delta$  7.56 (dd, 1H CH), 8.14 (dd, 1H CH), 8.07 (d, 1H CH).  $^{13}\text{C}$  ( $\text{CDCl}_3$ ):-127.3, 123.8, 147.1, 141.3, 113.6, 69.2, 156.7.

## Conclusion

An efficient Knoevenagel condensation reaction was carried out in short reaction times using  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  as a commercial catalyst and water as the solvent under milder conditions. The most attractive features of this protocol are its good conversions, easy workup and short reaction times, making it a useful practical method for the synthesis of adducts.

## Acknowledgement

We are grateful to the Principal Dr. D. R. Patil R.C. Patel ACS College, Shirpur and Department of chemistry for providing laboratory and technical support to this work.

## References

- [1] Tundo, P.; Anastas, P. T. *Green Chemistry: Challenging Perspectives*, Oxford Science: Oxford, 1999.
- [2] Pellerin, C. Chemistry goes Green. In *ejournal USA: Global Issues*; June 2005.
- [3] Li, C.-J. *Chem. Rev.* **1993**, 93, 2023. doi:10.1021/cr00022a004
- [4] Jones, G.; Wiley: New York, **1967**; vol. 15, 204-599.
- [5] Saeed, B.; Morteza, B.; Shohreh, H.; Peyman, S. *Synth. Commun.* **2006**, 36, 3703-3711.
- [6] Junjie, H.; Yanfen, J.; Yingpeng, S.; Xuegong, S.; Xinfu, P. *Catal. Commun.* **2008**, 9, 2077-2079.
- [7] Zhou, Z.; Sun, Y. *Synth. Commun.* **2011**, 41, 3162-3168.

.....

- [8] Rao P S & Venkataratnam R V, *Tetrahedron Lett*, 32, 1991, 5821.
- [9] Lehnert W, *Tetrahedron Lett*, 54, 1970, 4723.
- [10] Texier-Boullet F & Faucaud A, *Tetrahedron Lett*, 23, 1982, 4927
- [11] Gawande M B & Jayaram M V, *Catal Commun*, 7(12), 2006, 931
- [12] Moison H, Texier Boullet F & A, *Tetrahedron*, 43, 1987, 537
- [13] Wang Q L, Ma, Y D & Zuo B J, *Synth Commun*, 27, 1997, 4107
- [14] Ren Y M & Cai C, *Synth Commun*, 37, 2007, 2819
- [15] Pasha M A & Manjula K, *J Saudi Chem Soc*, 15(3), 2011, 283
- [16] Gill C, Pandhare G, Raut R, Gore V & Gholap S, *Bull Cai Soc India*, 7, 2008, 153
- [17] Balalaie S, Bararjanian M, Hekmat S & Salehi P, *Synth Commun*, 36, 2006, 2549
- [18] Abaee M S, Mojtahedi M M, Zahedi M M & Khanalizadeh G, *Arkivoc*, 2006, 10, 48
- [19] Hangarge R V, Jarikote D V & Shingare M S, *Green Chem*, 4, 2002, 266.
- [20] S.Wang, Z. Ren, W. Cao, Tong. *Synth. Commun.*, 2001, 31, 673-677.
- [21] T.S.Jin, X.Wang, L.B. Liu, T.S. Li, J. Chem.Res., 2006, 6, 346-347.
- [22] T.S. Jin, J.S. Zhang, A.Q. Wang, T.S. Li, *Synth. Commun.*, 2004, 34, 2611.
- [23] F.Bigi, S. Carloni, L. Ferrari, R. Maggi, A. Mazzacani, G. Sartori, *Tetrahedron Lett.*, 2001, 42, 5203.
- [24] Deshmukh M B, Patil S S, Jadhav S D and Pawar P B 2012 *Synth. Commun.* 42 1172-1175.