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## ALUMINA-AMMONIUM ACETATE AS AN EFFICIENT REAGENT FOR THE ONE-POT SYNTHESIS OF *CIS*-2,4,5-TRIARYLIMIDAZOLINES FROM AROMATIC ALDEHYDES

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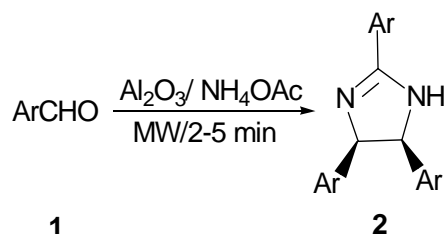
**Abstract** – A simple, efficient, and new method has been developed for the synthesis of 2,4,5-triarylimidazolines from aldehydes through a one-pot reaction of aldehydes in the presence of alumina-ammonium acetate under solvent-free conditions using microwave irradiation. This method is easy, rapid, one-pot and good to high-yielding reaction for the synthesis of 2,4,5-triarylimidazolines.

2,4,5-Triarylimidazolines are good precursors for the synthesis of imidazoles and diarylethylenediamines that can be used as chiral ligands in asymmetric synthesis.<sup>1</sup> The most important method for the synthesis of 2,4,5-triarylimidazolines is the reaction of aromatic aldehydes with ammonia to give the diimine compounds, *N,N'*-bis(arylmethylidene)arylmethanediamines, and followed by heating with strong base to form triarylimidazolines (Scheme 1).<sup>2</sup> Recently, new methods have been reported for the synthesis of triarylimidazolines using of HMDS in the presence of Lewis acids such as ZnCl<sub>2</sub><sup>3</sup> or without any catalyst under solvent-free conditions using microwave irradiation.<sup>4</sup> The application of microwave energy to accelerate organic reactions is of increasing interest and offers several advantages over conventional techniques.<sup>5</sup> As part of our efforts to explore the utility of mixture of alumina with ammonium acetate for the synthesis of organic compounds under microwave irradiation,<sup>6</sup> we report a new method for the preparation of *cis*-triarylimidazolines from aldehydes in the presence of a mixture of alumina with ammonium acetate under solvent-free conditions using microwave irradiation. (Scheme 1, Table 1).

The reaction of benzaldehyde (**1a**), chosen as a model compound, was studied in the presence of a mixture of alumina with several ammonium salts. Initially, we carried out the reaction of benzaldehyde in

a mixture of alumina with ammonium acetate under microwave irradiation to afford the corresponding *cis*-2,4,5-triphenylimidazoline in 80% yield after 2 min. When this reaction was carried out in methanol for 3 h it afforded the corresponding *cis*-2,4,5-triphenylimidazoline in 10% yield. Ammonium formate ( $\text{HCO}_2\text{NH}_4$ ) was not as effective as ammonium acetate and gave the required product in 35% yield under microwave irradiation. Other ammonium salts ( $\text{NH}_4\text{Cl}$ ,  $\text{NH}_4\text{Br}$ ,  $\text{NH}_4\text{PF}_6$ ,  $\text{NH}_4\text{I}$  and  $\text{NH}_4\text{NO}_3$ ) were not effective and did not give such product.

These results prompted us to extend this process to other aromatic aldehydes. Interestingly, aromatic aldehydes reacted smoothly in a mixture of alumina with ammonium acetate under microwave irradiation to produce the corresponding *cis*-triarylimidazolines in good to excellent yields (Table 1 and Scheme 2). As shown in Table 1, substituted benzaldehydes in the presence of a mixture of alumina with ammonium acetate, afforded the desired products in good to high yields (**2a-2h**). Naphthalenecarbaldehydes also reacted in the presence of a mixture of alumina with ammonium acetate under microwave irradiation to give the desired compounds in good yields (**2i, 2j**). The reactions were clean with no tar formation and can be carried out in a one-step operation of aldehydes with ammonium acetate for the synthesis of *cis*-triarylimidazolines.



Scheme 2

Table 1. One-pot Synthesis of *cis*-triarylimidazolines from aldehydes in the presence of alumina-supported ammonium acetate under microwave irradiation.

Product <b>2</b>	Ar- <b>1</b>	Time (min)	Yield (%)	Product <b>2</b>	Ar- <b>1</b>	Time (min)	Yield (%)
<b>a</b>	$\text{C}_6\text{H}_5$ - <sup>4a</sup>	2	80(85)	<b>f</b>	<i>p</i> - $\text{BrC}_6\text{H}_4$ - <sup>4a</sup>	3	53(83)
<b>b</b>	<i>p</i> - $\text{MeC}_6\text{H}_4$ - <sup>4a</sup>	3	79(82)	<b>g</b>	<i>m</i> - $\text{O}_2\text{NC}_6\text{H}_4$ -	2	75
<b>c</b>	<i>p</i> - $\text{ClC}_6\text{H}_4$ - <sup>4a</sup>	2	78(83)	<b>h</b>	<i>o</i> - $\text{ClC}_6\text{H}_4$ -	4	56
<b>d</b>	<i>p</i> - $\text{MeOC}_6\text{H}_4$ - <sup>4a</sup>	4	70(86)	<b>i</b>	$\alpha$ -Naphthyl	5	68
<b>e</b>	<i>p</i> - $(\text{CH}_3)_2\text{CHC}_6\text{H}_4$ -	5	72	<b>j</b>	$\beta$ -Naphthyl	4	76

In summary, simple work-up, low use of solvents, fast reaction rates, mild reaction conditions, good yields and the relatively clean reactions with no tar formation make this method an attractive and a useful contribution to present methodologies.

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## EXPERIMENTAL

**General:** All chemicals were commercial products and distilled or recrystallized before use. All melting points were obtained by a Buchi 510 and are uncorrected. A commercially available pulse microwave at 2450 MHz (900 W) was used in all experiments. IR spectra were determined using a FT-IR Bruker-Vector 22. NMR spectra were taken with a DMX-500 Bruker Avance instrument with the chemical shifts being reported as  $\delta$  ppm and couplings expressed in Hertz. Silica gel column chromatography was carried out with Silica gel 100 (Merck No. 10184). Merck Silica-gel 60 F254 plates (No. 5744) were used for the preparative TLC. Aluminiumoxide 90 active acidic (activity stage I) was used for the reactions (Merck No. 1078).

### Preparation of *cis*-Triarylimidazolines:

**General Procedure:** This solvent-free reaction is operationally simple. 10 Mmol of the reagent was prepared by the combination of ammonium acetate (0.77 g, 10 mmol, finely ground) and alumina ( $\text{Al}_2\text{O}_3$ , acidic, 2.5 g) in a mortar and pestle by grinding them together until a fine, homogeneous, powder was obtained (5-10 min). The aldehyde (9 mmol) was added to this reagent and the mixture was irradiated in a microwave for 2-5 min using 600 W. (A kitchen-type microwave instrument was used in all experiments). The mixture was then washed with 200 mL of EtOAc. The solvent was evaporated. Chromatography of the residue through a plug of silica gel with EtOAc/*n*-hexane (1:9 to 5:5) and evaporation of the solvent under reduced pressure gave the pure products in 53-90% yields. All products gave satisfactory spectral data in accord with the assigned structures and literature reports.<sup>4a</sup> For new compounds spectral data are reported as following:

#### *cis*-2,4,5-Tris(*p*-isopropylphenyl)imidazoline (2e):

This imidazoline was prepared in the general way and had mp 222-224°C (ethanol). <sup>1</sup>H-NMR ( $\text{CDCl}_3/\text{TMS}$ -500 MHz): 1.05 (6H, d,  $J=6.8$  Hz), 1.22 (6H, d,  $J=6.8$  Hz), 1.26 (6H, d,  $J=6.8$  Hz), 2.66 (2H, sep,  $J=6.8$  Hz), 2.89 (1H, sep,  $J=6.9$  Hz), 4.90 (2H, s), 6.57 (4H, d,  $J=7.9$  Hz), 6.78 (4H, d,  $J=7.9$  Hz), 7.46 (2H, d,  $J=8.1$  Hz) 8.52 (2H, d,  $J=8.1$  Hz), 10.93 (1H, br); <sup>13</sup>C-NMR ( $\text{CDCl}_3/\text{TMS}$ -125.7 MHz): 23.53, 23.66, 23.73, 33.52, 34.03, 65.70, 120.75, 125.56, 127.03, 129.82, 130.66, 132.18, 148.23, 152.82, 165.06;

IR (KBr): 3220 (-NH), 1620 (C=N)  $\text{cm}^{-1}$ ; MS  $m/z$ : 424 ( $\text{M}^+$ ). Anal. Calcd for  $\text{C}_{30}\text{H}_{36}\text{N}_2$ . C, 84.90; H, 8.49; N, 6.60. Found: C, 84.77; H, 8.41; N, 6.80.

***cis*-2,4,5-Tris(*m*-nitrophenyl)imidazoline (2g):**

This imidazoline was prepared in the general way and had mp 130-142° C (ethanol).  $^1\text{H-NMR}$ ,  $\delta_{\text{H}}$  ( $\text{CD}_3\text{SOCD}_3$ , TMS): 5.82 (s, 2H), 7.32-7.45 (m, 4H), 7.81-7.89 (m, 5H), 8.44-8.53 (m, 3H), 8.89 (s, 1H);  $^{13}\text{C-NMR}$ ,  $\delta_{\text{C}}$  ( $\text{CDCl}_3$ , TMS): 61.04, 121.99, 122.29, 122.56, 126.07, 129.61, 130.75, 131.46, 134.20, 142.25, 147.50, 148.34, 162.97; IR (KBr): 3379 (-NH), 1610 (C=N)  $\text{cm}^{-1}$ ; MS  $m/z$ : 433 ( $\text{M}^+$ ). Anal. Calcd for  $\text{C}_{21}\text{H}_{15}\text{N}_5\text{O}_6$ . C, 58.20; H, 3.46; N, 16.16. Found: C, 58.45; H, 3.66; N, 16.32.

***cis*-2,4,5-Tris(*o*-chlorophenyl)imidazoline (2h) :**

This imidazoline was prepared in the general way and had mp 132-134° C (ethanol).  $^1\text{H-NMR}$ ,  $\delta_{\text{H}}$  ( $\text{CD}_3\text{SOCD}_3$ , TMS): 6.04 (s, 2H), 6.94-7.01 (m, 4H), 7.09-7.26 (m, 4H), 7.36-7.48 (m, 3H), 7.97 (d, 1H,  $J=7.5$  Hz);  $^{13}\text{C-NMR}$ ,  $\delta_{\text{C}}$  ( $\text{CDCl}_3$ , TMS): 61.79, 123.26, 127.22, 128.26, 129.61, 130.41, 130.66, 130.98, 131.93, 132.03, 132.20, 132.81, 135.15, 164.88; IR (KBr): 3200 (-NH), 1610 (C=N)  $\text{cm}^{-1}$ ; MS  $m/z$ : 400 ( $\text{M}^+$ ). Anal. Calcd for  $\text{C}_{21}\text{H}_{15}\text{N}_2\text{Cl}_3$ . C, 62.76; H, 3.74; N, 6.97. Found: C, 62.96; H, 3.98; N, 6.97.

***cis*-2,4,5-Tris( $\alpha$ -naphthyl)imidazoline (2i):**

This imidazoline was prepared in the general way and had mp 240-242° C (ethanol).  $^1\text{H-NMR}$  ( $\text{CD}_3\text{SOCD}_3/\text{TMS}$ -500 MHz): 6.39 (2H, s), 6.98-7.01 (3H, m), 7.09-7.27 (6H, m), 7.36 (2H, d,  $J=8.1$  Hz), 7.46-7.59 (6H, m), 7.76 (2H, d,  $J=8.2$  Hz), 7.92-7.97 (3H, m), 8.81 (1H, m);  $^{13}\text{C-NMR}$  ( $\text{CD}_3\text{SOCD}_3/\text{TMS}$ -125.7 MHz): 66.6, 125.3, 125.6, 126.0, 127.1, 127.6, 127.7, 127.8, 128.1, 128.3, 129.0, 132.7, 132.8, 134.4, 138.4, 164.25; IR (KBr): 3140 (-NH), 1590 (C=N)  $\text{cm}^{-1}$ ; MS  $m/z$ : 448 ( $\text{M}^+$ ). Anal. Calcd for  $\text{C}_{33}\text{H}_{24}\text{N}_2$ . C, 88.39; H, 5.36; N, 6.25. Found: C, 88.22; H, 5.45; N, 6.08.

***cis*-2,4,5-Tris( $\beta$ -naphthyl)imidazoline (2j):**

This imidazoline was prepared in the general way and had mp 208-209°C (ethanol).  $^1\text{H-NMR}$  ( $\text{CD}_3\text{SOCD}_3/\text{TMS}$ -500 MHz): 6.39 (2H, s), 6.92-7.03 (3H, m), 7.06-7.13 (2H, m), 7.14-7.23 (4H, m), 7.33 (2H, d,  $J=6.9$  Hz), 7.46-7.51 (3H, m), 7.55-7.59 (2H, m), 7.76 (2H, d,  $J=8.5$  Hz), 7.92-7.97 (3H, m), 8.82 (1H, m);  $^{13}\text{C-NMR}$  ( $\text{CD}_3\text{SOCD}_3/\text{TMS}$ -125.7 MHz): 65.16, 122.98, 124.31, 124.79, 124.86, 124.92, 125.19, 125.50, 126.40, 127.30, 127.36, 127.42, 128.09, 128.56, 130.57, 131.51, 132.85, 133.45, 165.73; IR (KBr): 3412 (-NH), 1620 (C=N)  $\text{cm}^{-1}$ ; MS  $m/z$ : 448 ( $\text{M}^+$ ). Anal. Calcd for  $\text{C}_{33}\text{H}_{24}\text{N}_2$ . C, 88.39; H, 5.36; N, 6.25. Found: C, 88.18; H, 5.48; N, 5.98.

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