**Lanthanum Trichloride (LaCl$_3$): An Efficient Catalyst for Conjugate Addition of Amines to Electron-Deficient Olefins**

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**Abstract:** Electron-poor alkenes undergo rapid conjugate addition with a wide range of amines in the presence of lanthanum trichloride at room temperature to produce the corresponding 2-amino compounds in excellent yields.

**Keywords:** Amines, olefins, lanthanum trichloride, 2-amino compounds.

**INTRODUCTION**

Aza-Michael reaction is widely recognized as one of the most important carbon- nitrogen bond-forming conjugate addition reactions in synthetic organic chemistry [1]. The versatility of the conjugate additions is mainly due to the large variety of nucleophiles and acceptors that can be used. The obtained 2-amino compounds are present as structural components in a number of biologically active natural products (taxol), antibiotics ($\beta$-lactams) and chiral auxiliaries [2]. The most common method for the preparation of 2-amino compounds is the 1, 4-addition of amines (nucleophiles) to the $\alpha, \beta$-unsaturated systems. These methods are generally require basic or acidic activators [3]. In order to overcome some of the limitations, various Lewis acids [4], ionic liquids [5], microwave induced [6], Pd-compounds [7], and solid supports [8] like clay, Al$_2$O$_3$, silica gel induced reactions have been reported. However, many of these procedures often require a large excess of reagents, long reaction time and drastic reaction conditions [9]. Therefore, the development of simple, more convenient and eco-friendly approaches is encouraging. The catalyst, lanthanum trichloride (LaCl$_3$) is known for various organic transformations in the literature as a mild, inexpensive and moisture stable Lewis acid [10]. However, there are no reports on conjugate addition reactions with LaCl$_3$ and with an ever-increasing quest for new catalysts, herein, we wish to report the use of LaCl$_3$ as a novel and efficient catalyst for 1, 4-addition of various nucleophiles to electron-deficient olefins successfully.

**RESULTS AND DISCUSSION**

In a typical experiment, the conjugate addition of benzyl amine to acrylonitrile was carried out with similar reaction conditions to afford the corresponding 3-benzylamino propionitrile in 92% yield (entry h) and the reaction was completed within 2.5h. Encouraged by these results, the reactions were carried out with various amines such as phenyl ethyl amine, N-phenyl piperazine, morpholine, diisopropyl amine and aniline with ethylacrylate and acrylonitrile to afford the corresponding 1, 4-addition of Aza-Michael products in very good to excellent yields. Primary amines and alicyclic amines reacted faster than aniline and in a similar manner, ethylacrylate reacted faster than acrylonitrile. Among all the reactions, diisopropyl amine with ethylacrylate gave the lowest yield (84%) of the addition product and benzyl amine with ethylacrylate gave high yield (95%). Whereas, the aniline reaction with ethylacrylate took maximum reaction (4.0h) time and benzyl amine with ethylacrylate was completed within minimum reaction time (2.0h). In general, all the reactions were completed within 2.0 to 4.0h of reaction time and the obtained yields of Aza-Michael products were also in 84-95%. All the products were confirmed by their $^1$H NMR, IR and mass spectroscopy and the data compared with literature reports. The scope and generality of this protocol were illustrated with respect to various $\alpha, \beta$-ethylenic compounds and amines and the obtained results are summarized in Table I.

**CONCLUSION**

In conclusion, we have demonstrated an efficient methodology for conjugate addition of various amines with electron deficient olefins using a mild Lewis acid catalyst lanthanum trichloride. All the reactions were carried out at room temperature in dichloromethane solvent. The present procedure provides a convenient and general protocol for the preparation of $\beta$-amino compounds in excellent yields.
### Table 1. Conjugate Addition of Amines to Ethylenic Compounds Catalyzed by LaCl₃

<table>
<thead>
<tr>
<th>Entry</th>
<th>Amines (1)</th>
<th>Ethylenic Compound (2)</th>
<th>Product (3)</th>
<th>Reaction Time (h)</th>
<th>Yield (%)</th>
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<tr>
<td>a</td>
<td>[ \text{Ph} - \text{N} - \text{NH} ]</td>
<td>[ \text{OEt} ]</td>
<td>[Image]</td>
<td>2.0</td>
<td>95</td>
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<tr>
<td>b</td>
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<td>[Image]</td>
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<td>92</td>
</tr>
<tr>
<td>c</td>
<td>[ \text{Ph} - \text{N} - \text{NH} ]</td>
<td>[ \text{CN} ]</td>
<td>[Image]</td>
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<td>89</td>
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<tr>
<td>d</td>
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<td>[ \text{CO₂Et} ]</td>
<td>[Image]</td>
<td>2.5</td>
<td>91</td>
</tr>
<tr>
<td>e</td>
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<td>[ \text{OEt} ]</td>
<td>[Image]</td>
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<td>f</td>
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<td>89</td>
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<td>[ \text{CN} ]</td>
<td>[Image]</td>
<td>3.0</td>
<td>90</td>
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</table>

**EXPERIMENTAL SECTION**

**General Methods**

Melting points were recorded on Buchi R-535 apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer FT-IR 240-c spectrophotometer using KBr optics. ¹H NMR spectra were recorded on Gemini-200 spectrometer in CDCl₃ using TMS as internal standard. Mass spectra were recorded on a Finnigan MAT 1020 mass spectrometer operating at 70eV.

**General Procedure**

To a mixture of amine (2 mmol) and acryl compound (2.0 mmol) in dichloromethane (10 ml) was added lanthanum trichloride (0.2 mol%). The resulting reaction mixture was stirred at room temperature for a specified period (Table I). After completion of the reaction as indicated by TLC, the reaction mixture was diluted by adding dichloromethane (20 ml). The reaction mixture was washed with water, followed by brine and the organic layer was dried over Na₂SO₄ and concentrated under reduced pressure. The obtained crude
products were purified by column chromatography using silica gel (60-120 mesh) by eluting with ethyl acetate and hexane mixture in 3:7 ratios. All the products were characterized by \( ^1 \)H NMR, IR and mass spectroscopy.

**Spectral Data for Selected Compounds**

**Ethyl 3-(N-benzylamino)-propionate (3a)**

IR (neat): v 3254, 3041, 2968, 2837, 1728, 1612, 1591, 1504, 1472, 1355, 1286, 1131, 1058, 1016, 985, 867, 821, 794, 739 cm\(^{-1}\). \( ^1 \)H NMR (CDCl\(_3\)): \( \delta \) 1.23 (t, 3H, J = 7.0 Hz), 2.15 (brs, 1H), 2.50 (t, 2H, J = 6.2 Hz), 3.70 (s, 2H), 4.15 (q, 2H, J = 7.0 Hz), 7.22-7.40 (m, 5H). EIMS: m/z (%): 207 (m + 25), 178 (18), 134 (100), 106 (120), 91 (25), 77 (38), 65 (10), 52 (20).

**Ethyl 3-(N-phenylpiperazine)-propionate (3d)**

IR (neat): v 3444, 2975, 2821, 1618, 1599, 1500, 1455, 1380, 1231, 1056, 1015, 927, 864, 760, 694 cm\(^{-1}\). \( ^1 \)H NMR (CDCl\(_3\)): \( \delta \) 1.26 (t, 3H, J = 7.0 Hz), 2.45-2.55 (m, 6H), 2.68 (t, 2H, J = 6.8 Hz), 3.70 (t, 4H, J = 4.5 Hz), 4.20 (q, 2H, J = 7.0 Hz). EIMS: m/z (%): 262 (m + 40), 233 (21), 189 (100), 161 (15), 119 (26), 91 (10), 84 (36), 77 (85), 65 (14), 52 (12), 42 (20).

**References and Notes**


