



## PEG: An Efficient Green Solvent for Organocatalytic Asymmetric Michael Addition

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### INTRODUCTION

Green chemistry strongly influences chemical research, and there is still a big challenge respecting the requirement to use 'greener' reaction conditions. An important aspect of this field is the replacement of volatile organic solvent by non-flammable, non-volatile, non-toxic and inexpensive "green solvents". In this regard, polyethylene glycol polymers (PEGs) have also been considered as a new class of green solvents.<sup>1</sup>

### RESULTS AND DISCUSSION

We have recently developed a new class of catalyst and their applications on organocatalytic process in aqueous media.<sup>2</sup> In the present work, we expanded our studies to evaluation in asymmetric Michael addition of aldehyde to  $\beta$ -nitrostyrene using PEG-400 (Table 1).

**Table 1.** Studies and Optimization of the Reaction Parameters.

Entry	Solvent	Yield <sup>[a]</sup>	ee <sup>[b]</sup>	dr <sup>[c]</sup>	Time
1	PEG-400	100%	97%	80:20	2h
2	PEG-400 <sup>[d]</sup>	92%	95%	76:24	1h
3	PEG-400 <sup>[e]</sup>	47%	98%	88:12	44h
4	PEG-400 <sup>[f]</sup>	99%	97%	87:13	4h

<sup>[a]</sup>Isolated yield. <sup>[b]</sup>The ee values were determined by chiral HPLC. <sup>[c]</sup>The d.r. values were determined by <sup>1</sup>H NMR spectroscopy and HPLC. <sup>[d]</sup>The reaction was performed at room temperature; <sup>[e]</sup>1 mol% of catalyst **1a**. <sup>[f]</sup>5 mol% of catalyst **1a**.

The best reaction condition is show in entry 4 of table 1, by using 5 mol% of catalyst **1a** having PEG-400 as solvent in a 2M concentration. Others co-catalysts were also evaluated, however, benzoic acid delivered the desired product with superior

results. Trying to improve the d.r. relationship, the structure of the organocatalyst was also evaluated.

**Table 2.** Organocatalyst Screening for the Michael Addition

Catalysts	Yield <sup>[a]</sup>	ee <sup>[b]</sup>	dr <sup>[c]</sup>	Time
<b>C<sub>6</sub>H<sub>5</sub>SC<sub>6</sub>H<sub>13</sub> (1a)</b>	<b>99%</b>	<b>97%</b>	<b>87:13</b>	<b>4h</b>
C <sub>6</sub> H <sub>5</sub> SC <sub>2</sub> H <sub>5</sub> (1b)	44%	96%	89:11	6h
C <sub>6</sub> H <sub>5</sub> SC <sub>12</sub> H <sub>25</sub> (1c)	18%	97%	90:10	5h
C <sub>6</sub> H <sub>5</sub> OC <sub>6</sub> H <sub>13</sub> (2a)	99%	96%	87:13	4h
C <sub>6</sub> H <sub>5</sub> OC <sub>2</sub> H <sub>5</sub> (2b)	78%	98%	83:17	3h

<sup>[a]</sup>Isolated yield. <sup>[b]</sup>The ee values were determined by chiral HPLC. <sup>[c]</sup>The d.r. values were determined by <sup>1</sup>H NMR spectroscopy and HPLC.

From these results we could observed that catalyst **1a** and benzoic acid as co-catalyst delivered the desired product in excellent levels of selectivity.

### CONCLUSION

In summary we have demonstrated a highly stereoselective Michael addition of aldehydes to  $\beta$ -nitrostyrene using PEG-400 as green solvent. Additional studies on both solvent and catalyst reusability are ongoing.

### ACKNOWLEDGEMENTS



### REFERENCES

- Capelo, C.; Fisher, U.; Hungerbuhler, K. *Green Chem.*, **2007**, 9, 927.
- [a] Deobald, A. M.; Corrêa, A. G.; Rivera, D. G.; Paixão, M. W. *Org. Biomol. Chem.* **2012**, 10, 7681. [b] Feu, K. S.; Deobald, A. M.; Narayanaperumal, S.; Corrêa, A. G.; Paixão, M. W. *Eur. J. Org. Chem.* **2013**, DOI: 10.1002/ejoc.201300431.