

## SHORT COMMUNICATION

### SILICA SULFURIC ACID: A VERSATILE AND REUSABLE HETEROGENEOUS CATALYST FOR THE SYNTHESIS OF N-ACYL CARBAMATES AND OXAZOLIDINONES UNDER SOLVENT-FREE CONDITIONS

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**ABSTRACT.** Silica sulfuric acid catalyzes efficiently the reaction of carbamates and oxazolidinones with anhydrides under solvent-free conditions. All the reactions were done at room temperature and the N-acyl carbamates and oxazolidinones were obtained with high yields and purity *via* an easy work-up procedure. This method is attractive and is in a close agreement with green chemistry.

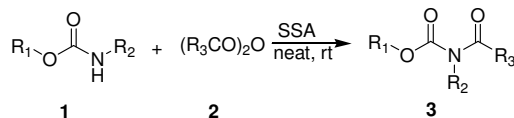
**KEY WORDS:** N-Acyl carbamates, N-Acyl oxazolidinones, Silica sulfuric acid, Solvent-free

## INTRODUCTION

N-Acyl carbamates and oxazolidinones are versatile building blocks in the synthesis of natural products, pharmaceuticals, agricultural chemicals, and bioactive molecules [1]. Numerous methods have been reported for the synthesis of N-acyl carbamates and oxazolidinones. The most commonly used method involves the reaction of carbamates and oxazolidinones with acid chlorides or anhydrides in basic reaction conditions [2]. Recently, Lewis acids [3], such as H<sub>2</sub>SO<sub>4</sub>, HBr, ZnCl<sub>2</sub>, MgBr<sub>2</sub>·OEt<sub>2</sub> have been shown to be effective for the synthesis of N-acyl carbamates and oxazolidinones. However, most of these procedures have significant drawbacks such as long reaction times, low yields, harsh reaction conditions, difficult work-up and use of environmentally toxic reagents or media. Hence, there is still a need to develop a practical and applicable method for the synthesis of N-acyl carbamates and oxazolidinones.

In recent years, the use of heterogeneous catalysts has received considerable interest in various disciplines including organic synthesis. They are advantageous over their homogeneous counterparts due to the prime advantage that in most of the cases the catalyst can be recovered easily and reused. Silica sulfuric acid (SSA) has been used as an efficient heterogeneous catalyst for many organic transformations because of its low cost, ease of preparation, catalyst recycling, and ease of handling [4].

In continuation of our work on the application of heterogeneous catalysts to the development of simplified synthetic methodologies [5], we observed that SSA could act as an efficient catalyst for the synthesis of N-acyl carbamates and oxazolidinones by reaction of carbamates and oxazolidinones with anhydrides (Scheme 1).



Scheme 1

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## RESULTS AND DISCUSSION

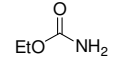
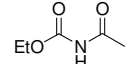
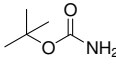
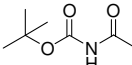
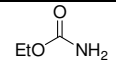
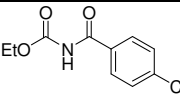
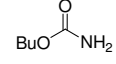
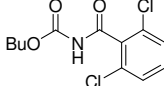
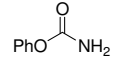
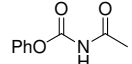
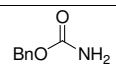
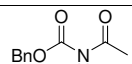
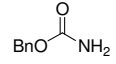
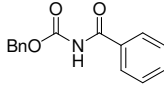

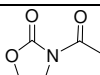
We started to study this condensation reaction by examining the amount of catalyst for the reaction involving phenyl carbamate (1 mmol) and acetic anhydride (1.2 mmol) to afford the product phenyl acetylcarbamate under solvent-free conditions at room temperature. As can be seen from Table 1, the best result was obtained with 2 mol% SSA under solvent-free conditions and gave the product in high yield.


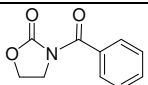
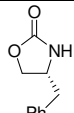
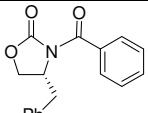
Table 1. The amounts of catalyst optimization for the synthesis of phenyl acetylcarbamate<sup>a</sup>.

Entry	SSA (mol%)	Time (min)	Yield (%) <sup>b</sup>
1	0	60	16
2	1	5	78
3	2	3	92
4	3	3	92
5	4	2	90
6	5	2	92

<sup>a</sup>Reaction conditions: phenyl carbamate (1 mmol); acetic anhydride (1.2 mmol); room temperature; neat. <sup>b</sup>Isolated yield.

Table 2. Preparation of N-acyl carbamates and oxazolidinones catalyzed by SSA<sup>a</sup>.

Entry	Carbamate	Anhydride	Product	Time (h)	m.p. (°C) (lit. m.p.)	Yield (%) <sup>b</sup>
<b>a</b>		(MeCO) <sub>2</sub> O		5	76-77	89
<b>b</b>		(MeCO) <sub>2</sub> O		3	77-78 (79-80 [6])	87
<b>c</b>		(4-ClPhCO) <sub>2</sub> O		15	105-106	84
<b>d</b>		(2,6-Cl <sub>2</sub> PhCO) <sub>2</sub> O		20	110-112	89
<b>e</b>		(MeCO) <sub>2</sub> O		3	119-121 (120-122 [3d])	92
<b>f</b>		(MeCO) <sub>2</sub> O		3	106-107 (104-105 [3d])	91
<b>g</b>		(PhCO) <sub>2</sub> O		60	109-110 111-113 [3d])	86
<b>h</b>		(MeCO) <sub>2</sub> O		5	59-60 63-64 [7]	86

<b>i</b>		(PhCO) <sub>2</sub> O		30	169-170 167-168 [7]	93
<b>j</b>		(MeCO) <sub>2</sub> O		45	110-111 (109 [2a])	79

<sup>a</sup>Reaction conditions: carbamate (1 mmol); anhydride (1 mmol); SSA (0.02 mol); room temperature; neat.

<sup>b</sup>Isolated yield.

SSA is environmentally benign and solid acid catalyzed the reaction of a variety of carbamates and oxazolidinones with anhydrides under solvent-free conditions at room temperature and reaction completed within 1 h. As indicated in Table 2, in all cases the reaction gives the products in good yields and high selectivity and prevents problems which many associate with solvent use such as cost, handling, safety and pollution.

The reusability of the catalyst was checked by separating SSA from the reaction mixture by simple filtration, washing with CH<sub>2</sub>Cl<sub>2</sub>, and drying in a vacuum oven at 60 °C for 10 hours prior to reuse in subsequent reactions. The recovered catalyst can be reused at least three additional times in subsequent reactions without significant loss in product yield (Table 3).

Table 3. The effect of reusability of SSA catalyst on phenyl acetylcarbamate synthesis<sup>a</sup>.

Run	Cycle	Yield (%) <sup>b</sup>
1	0	92
2	1	90
3	2	88
4	3	86

<sup>a</sup>Reaction conditions: phenyl carbamate (1 mmol); acetic anhydride (1.2 mmol); SSA (0.02 mol); room temperature; neat. <sup>b</sup>Isolated yield.

To emphasize the effect of catalyst the model reaction between phenyl carbamate and acetic anhydride was described and different acidic catalysts were subjected to the reaction. All the reactions were run in the same conditions and similar amounts of catalysts (2 mol%) were used. As can be seen in Table 4, satisfactory results were obtained only with SSA (entry 8).

Table 4. Effect of acidic catalyst on the reaction of phenyl carbamate and acetic anhydride<sup>a</sup>.

Entry	Catalyst	Time (min)	Yield (%) <sup>b</sup>
1	<i>p</i> -TsOH	60	62
2	H <sub>2</sub> SO <sub>4</sub>	90	65
3	NaHSO <sub>4</sub>	120	45
4	NaHSO <sub>3</sub>	180	23
5	I <sub>2</sub>	15	82
6	ZnCl <sub>2</sub>	5	88
7	MgBr <sub>2</sub> ·OEt <sub>2</sub>	120	81
8	SSA	3	92

<sup>a</sup>Reaction conditions: phenyl carbamate (1 mmol); acetic anhydride (1.2 mmol); room temperature; neat. Isolated yield.

## CONCLUSIONS

In summary, we have developed a new practical and mild method for synthesis of N-acyl carbamates and oxazolidinones by the reaction of carbamates and oxazolidinones with anhydrides in the presence of SSA under solvent-free conditions. The use of an inexpensive reagent under mild reaction conditions, and with short reaction times and good yields makes this an attractive addition to existing procedures.

## EXPERIMENTAL

*General experimental methods.* NMR spectra were determined on Bruker AV-400 spectrometer (Switzerland) at room temperature using TMS as internal standard, coupling constants (*J*) were measured in Hz. IR spectra were recorded on a Bruker IFS-55 spectrometer (Switzerland). Elemental analyses were performed by a Vario-III elemental analyzer (Germany). Melting points were determined on a XT-4 binocular microscope (China) and were uncorrected. SSA was prepared according to literature [4a]. Commercially available reagents were used throughout without further purification unless otherwise stated. Products **3** are known compounds and their physical data, IR, and NMR spectra were essentially identical with those of the authentic samples. However, their structures were further established using elemental analysis.

*General procedure for the preparation of 3.* To a mixture of carbamate or oxazolidinone (1.0 mmol) and anhydride (1.2 mmol), SSA (8 mg, 0.02 mmol) was added. The mixture was stirred at room temperature for the given time (Table 2). After completion of the reaction (TLC), CH<sub>2</sub>Cl<sub>2</sub> (20 mL) was added, and the solid catalyst was removed by filtration. The solvent was evaporated and the crude product was purified by silica gel column chromatography using hexanes and ethyl acetate (3:1) as eluent. The spectral data for some new products are given below.

*Ethyl 4-chlorobenzoylcarbamate (3c).* White powder, m.p. 105-106 °C; IR (KBr)  $\nu$ : 3251, 1758, 1742 cm<sup>-1</sup>; <sup>1</sup>H-NMR (CDCl<sub>3</sub>, 400 MHz)  $\delta$ : 8.10 (s, 1H), 7.82-7.49 (m, 4H), 4.26 (q, 2H, *J* = 7.6 Hz), 1.32 (t, 3H, *J* = 7.6 Hz); Anal. calcd for C<sub>10</sub>H<sub>10</sub>ClNO<sub>3</sub>: C 52.76, H 4.43; found: C 52.86, H 4.35.

*Butyl 2,6-dichlorobenzoylcarbamate (3d).* White powder, m.p. 110-112 °C; IR (KBr)  $\nu$ : 3259, 1770 cm<sup>-1</sup>; <sup>1</sup>H-NMR (CDCl<sub>3</sub>, 400 MHz)  $\delta$ : 7.98 (s, 1H), 7.54-7.01 (m, 3H), 4.12 (t, 2H, *J* = 7.2 Hz), 1.65-1.56 (m, 2H), 1.33-1.26 (m, 2H), 0.97 (t, 3H, *J* = 7.2 Hz); Anal. calcd for C<sub>12</sub>H<sub>13</sub>Cl<sub>2</sub>NO<sub>3</sub>: C 52.76, H 4.43; found: C 52.86, H 4.35.

## ACKNOWLEDGEMENTS

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