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A Multicomponent Approach to Oxazolidinone Synthesis Catalyzed by Rare-Earth Metal Amides

Meixia Zhou,[a] Xizhou Zheng,[a] Yaorong Wang,[a] Dan Yuan,*[a] and Yingming Yao*[a]

Three-component reaction of epoxides, amines, and dimethyl carbonate catalyzed by rare-earth metal amides has been developed to synthesize oxazolidinones. 47 examples of 3,5-disubstituted oxazolidinones were prepared in 13-97% yields. This is a simple and most practical method which employs easily available substrates and catalysts, and is applicable to a wide range of aromatic and aliphatic amines, as well as mono-substituted epoxides. Scope of disubstituted epoxides is rather limited, which requires further study. Preliminary mechanistic study reveals two possible reaction pathways through intermediates of β-amino alcohols or amides.

Introduction

Oxazolidinones are important intermediates in organic synthesis,[1] which also find potential application as HIV-1 protease inhibitors, antibiotics, and antidepressant drugs.[2] Many methods have been developed to produce oxazolidinones, including carbonylation reaction of β-amino alcohols with CO_2 or dialkyl carbonates,[3] cycloaddition reaction of epoxides with isocyanates,[4] and reaction of CO_2 with propargylamines or ethyleneimines.[5] Among them, starting materials are either of limited availability (*e.g.*, isocyanates, propargylamines, and ethyleneimines), or highly toxic (*e.g.*, isocyanates). Kleij, Gao and others reported reactions of epoxides and carbamates, which generated 3-H and 3-aryloxazolidinones, whereas 3-alkyloxazolidinones were not accessible.[6] In recent years, a three-component reaction of amines, epoxides, and CO_2, has received increasing interests, as it employs easily available starting materials, and transforms CO_2 into value added compounds.[7] A modified version of the three-component reaction involves 1,2-dihaloethanes, amines and CO_2.[8] However, limitations such as addition of one or more equivalents of bases and largely excessive epoxides or dihaloethanes, and low activity of aliphatic amines have hindered their application. Recently, Jamieson *et al.* developed a modified three-component reaction replacing CO_2 with dialkyl carbonates. This reaction was mediated by phosphazene base BEMP,[9] which worked well with aliphatic amines, while reactions of aniline derivatives remain to be explored. Therefore, developing a more practical approach to a broad range of oxazolidinone synthesis is highly desirable.

Our group has reported rare-earth metal complexes that catalyzed oxazolidinone synthesis, through reaction of epoxides and isocyanates,[4f] as well as three-component reaction of CO_2, epoxides and anilines.[7d] As part of our ongoing studies on efficient synthesis of oxazolidinones, we studied three-component reaction of epoxides, amines and dialkyl carbonates catalyzed by readily available rare-earth metal amides RE(μ-Cl)Li[$(Me_3Si)_2N]_3(THF)_3$. A wide range of anilines and aliphatic amines reacted with epoxides and dialkyl carbonates, and generated 47 oxazolidinones in 13-97% yields, which is a most practical and widely applicable method to synthesize oxazolidinones.

Results and Discussion

A series of rare-earth metal amides RE(μ-Cl)Li[$(Me_3Si)_2N]_3(THF)_3$ [RE = La (**1**), Nd (**2**), Sm (**3**), Y (**4**), Yb (**5**)] were tested in catalyzing three-component reaction of aniline (**1a**), 2-(phenoxymethyl)oxirane (**2a**), and dimethyl carbonate (DMC) (Table 1). 5-(Phenoxymethyl)-3-phenyloxazolidin-2-one (**3a**) was obtained in 73-97% yields after 12 h reaction at 80 ℃ under neat conditions (Table 1, entries 2-6). In comparison, trace amount of product was detected without any catalyst (Table 1, entry 1). Catalytic activity of rare-earth metal amides decreased as ionic radii of metal ions decreased. Almost quantitative yield of 97% was obtained in the presence of La(μ-Cl)Li[$(Me_3Si)_2N]_3(THF)_3$ (**1**) (Table 1, entry 2). It is noteworthy that La[$(Me_3Si)_2N]_3$ (**6**) showed inferior activity comparing to that of complex **1** incorporating LiCl, suggesting that the presence of LiCl improves catalytic activity (Table 1, entry 7). Indeed, addition of LiCl into La[$(Me_3Si)_2N]_3$-catalyzed reaction led to an improved yield of 92% (Table 1, entry 8). LiCl-enhanced catalytic activity has been reported in rare-earth metal amide-catalyzed aldol reaction[10] and alkene epoxidation[11], attributing to cooperation of Ln and Li cations. Different reaction conditions, including substrate ratios, catalyst loadings, solvents and reaction time were then screened (Table S1), and the optimal condition is confirmed as follows: 2 mol% of complex **1**, 80 ℃, 12 h reaction time, substrate ratio of 2:1:2 (**1a**: **2a**: DMC), neat (Table 1, entry 2). Different dialkyl carbonates were also studied (Table 1, entries 9 and 10), and DMC is selected for further study as the reaction has the advantages of high-yielding, high atom economy, and easy purification due to low boiling point of DMC. Moreover, DMC is of low toxicity, which finds potential application in green and sustainable manufacturing.

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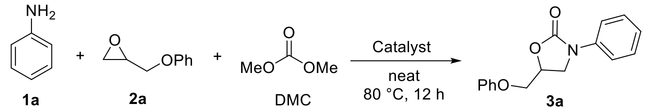
Table 1. Condition Screening for the Reaction of Aniline, 2-(Phenoxymethyl)oxirane, and Dimethyl Carbonate.[a]

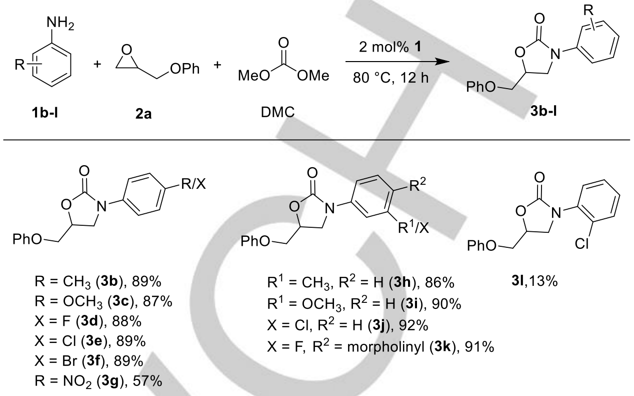


Entry	Catalyst	Yield(%)[b]
1	-	Trace
2	$La(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**1**)	97
3	$Nd(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**2**)	93
4	$Sm(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**3**)	89
5	$Y(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**4**)	88
6	$Yb(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**5**)	73
7	$La[(Me_3Si)_2N]_3$ (**6**)	81
8	$La[(Me_3Si)_2N]_3$ (**6**) + LiCl	92
9[c]	$La(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**1**)	95
10[d]	$La(\mu\text{-}Cl)Li[(Me_3Si)_2N]_3(THF)_3$ (**1**)	82

[a] Reaction conditions: aniline **1a** (2 mmol), 2-(phenoxymethyl)oxirane **2a** (1 mmol), dimethyl carbonate (2 mmol), catalyst (2 mol%), 80 ℃, 12 h, neat. [b] Determined by ^1H NMR spectroscopy based on 2-(phenoxymethyl)oxirane with 1,3,5-trimethoxybenzene as an internal standard. [c] Diethyl carbonate. [d] Diphenyl carbonate.

Under optimal conditions, the scope of the three-component reaction was studied (Table 2). Anilines bearing either electron-donating or withdrawing groups in *para* or *meta* positions were converted straightforwardly into corresponding oxazolidinones (products **3b**-**f**, **3h**-**k**) in 86-92% yields. The only low yield of 57% was obtained from reaction of *p*-nitroaniline (**1g**), because the strong electron-withdrawing substituent weakens its nucleophilicity. In addition, the reaction of aniline with *ortho*-substituents (*e.g.*, chloro group in **1l**) resulted in a poor yield of 13%, as a result of increased steric hindrance. This is the first example of 3-aryloxazolidinone preparation from three component reaction of epoxide, aniline, and dialkyl carbonate, proving a simple approach to synthesize oxazolidinones from easily available starting materials and catalysts. In addition, the reaction works under neat conditions, and produces MeOH as the only byproduct.

Table 2. Substrate Scope of Anilines[a]



R = CH_3 (**3b**), 89%
R = OCH_3 (**3c**), 87%
X = F (**3d**), 88%
X = Cl (**3e**), 89%
X = Br (**3f**), 89%
R = NO_2 (**3g**), 57%

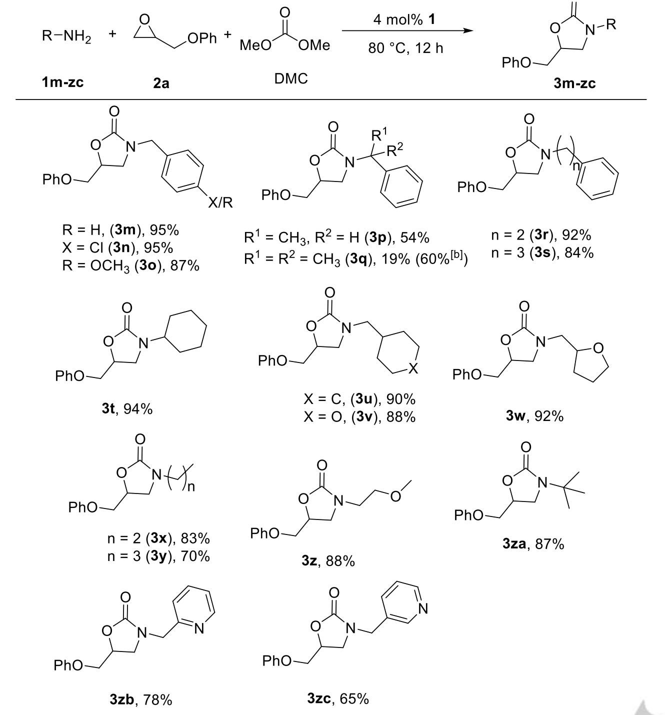
R^1 = CH_3, R^2 = H (**3h**), 86%
R^1 = OCH_3, R^2 = H (**3i**), 90%
X = Cl, R^2 = H (**3j**), 92%
X = F, R^2 = morpholinyl (**3k**), 91%

[a] Reaction conditions: aniline (2 mmol), 2-(phenoxymethyl)oxirane **2a** (1 mmol), dimethyl carbonate (2 mmol), complex **1** (0.02 mmol, 2 mol%), 80 ℃, 12 h, isolated yield.

Although three-component reaction of amines, CO_2 and epoxides also produces oxazolidinones, low to no activities of aliphatic amines is a common limitation of this method (*vide supra*).[7a-e,g,h] It is thus important to study the performance of rare-earth metal amides in catalyzing reaction of aliphatic amines, epoxides, and DMC. Under afore-established condition, the reaction of benzyl amine with 2-(phenoxymethyl)oxirane and DMC gave product **3m** in a moderate yield of 76% (Table S2, entry 1). Further optimization of reaction conditions revealed that 4 mol% catalyst loading gave rise to significantly improved yield of 95% (Table S2, entries 2-5).

Various aliphatic amines were studied and results are summarized in Table 3. Substituted benzyl amines reacted straightforwardly, which yielded desired products **3n** and **3o** in 95% and 87% yields, respectively. Bulkier α-substituted benzyl amines, *i.e.*, 1-phenylethan-1-amine and 2-phenylpropan-2-amine, reacted sluggishly, and generated oxazolidinones **3p** and **3q** in yields of 54% and 19%, respectively. The latter yield was improved to 60% through increasing catalyst loading to 8 mol%, whereas the BEMP-based system did not show any activity.[9c] Reactions of 2-phenylethan-1-amine and 3-phenylpropan-1-amine gave comparable yields of 92% (**3r**) and 84% (**3s**), respectively. Cyclic and linear aliphatic amines, including heteroatom-containing substrates, were studied and yields of desired oxazolidinones **3t-z** fell in the range of 70-94%. For sterically hindered 2-methylpropan-2-amine, the corresponding oxazolidinone **3za** was isolated in a good yield of 87%. Pyridin-2-ylmethanamine and pyridin-3-ylmethanamine were converted into oxazolidinones **3zb** and **3zc** in 78% and 65% yields, respectively. These results reveal that this rare-earth metal amide-catalyzed DMC-involved three component reaction is applicable to both aromatic and aliphatic amines, which is superior to that of CO_2-participated three-component reaction.

Table 3. Scope of Aliphatic Amines[a]



R = H, (**3m**), 95%
X = Cl (**3n**), 95%
R = OCH$_3$ (**3o**), 87%

R^1 = CH$_3$, R^2 = H (**3p**), 54%
R^1 = R^2 = CH$_3$ (**3q**), 19% (60%[b])

n = 2 (**3r**), 92%
n = 3 (**3s**), 84%

3t, 94%

X = C, (**3u**), 90%
X = O, (**3v**), 88%

3w, 92%

n = 2 (**3x**), 83%
n = 3 (**3y**), 70%

3z, 88%

3za, 87%

3zb, 78%

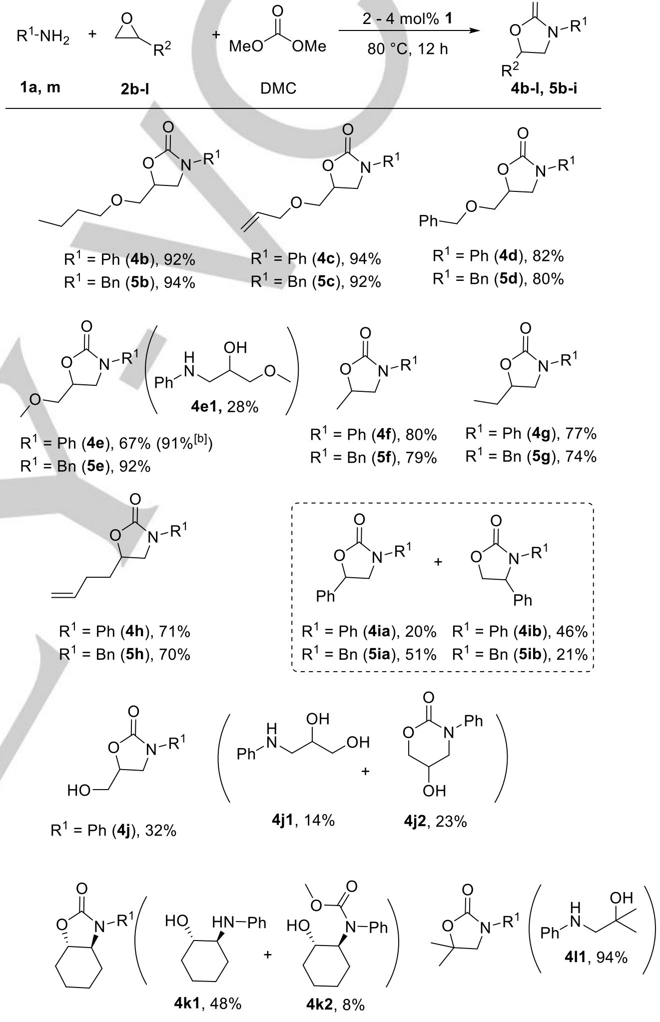
3zc, 65%

[a] Reaction conditions: amine (2 mmol), 2-(phenoxymethyl)oxirane **2a** (1 mmol), dimethyl carbonate (2 mmol), complex **1** (0.04 mmol, 4 mol%), 80 ℃, 12 h, isolated yield. [b] 8 mol% catalyst loading.

On the basis of amine scope study, different epoxides were investigated (Table 4). Monosubstituted epoxides bearing ether, alkyl, alkenyl, phenyl, or hydroxyl groups were converted into various oxazolidinones in 32-94% yields. Reactions of ether-containing epoxides yielded 3,5-disubstituted oxazolidinones in 80-94% yields (products **4b-d** and **5b-e**), without deactivating the catalyst. Reaction of methyl glycidyl ether produced oxazolidinone **4e** in 67% yield, along with β-amino alcohol **4e1** in 28% yield. Improved yield of 91% was obtained by increasing the catalyst loading to 4 mol%. Besides, epoxides bearing alkyl or alkenyl groups were also tolerated and generated corresponding oxazolidinones in yields of 70-80% (products **4f-h** and **5f-h**). Different regioselectivity was observed in reactions of styrene oxide, due to favorable ring-opening at benzylic positions. Mixtures of 4- and 5- substituted oxazolidinones were obtained in overall 66% and 72% yields, respectively. In addition, the reaction of epoxide bearing a hydroxyl group (*i.e.*, oxiran-2-ylmethanol) yielded oxazolidinone **4j** in 32% yield,[12a] along with β-amino alcohol **4j1** (14% yield),[12b] and oxazinanone **4j2** (23% yield),[12c] which was attributed to a reduced chemo-selectivity caused by the OH group.

Reactions of disubstituted epoxides proceeded sluggishly due to steric hindrance. Cyclohexene oxide was converted to *trans*-3-phenylhexahydrobenzooxazolidin-2-one **4k** as a single diastereomer in 36% yield, along with *trans*-configured β-amino alcohol **4k1** (48% yield),[13] and carbamate **4k2** (8% yield) (*vide infra*). Increasing the catalyst loading to 8 mol% led to improved yield of 67%. Reaction of 2,2-dimethyloxirane did not form oxazolidinone, but generated β-amino alcohol **4l1** almost exclusively. Al-aminotriphenolate complex-catalyzed reactions of disubstituted epoxides and phenyl carbamate gave better results (48-77% yields) under mild conditions (50 ºC, 2 mol% cat.).[6c]

Table 4. Scope of Epoxides[a]



R^1 = Ph (**4b**), 92%
R^1 = Bn (**5b**), 94%

R^1 = Ph (**4c**), 94%
R^1 = Bn (**5c**), 92%

R^1 = Ph (**4d**), 82%
R^1 = Bn (**5d**), 80%

4e1, 28%

R^1 = Ph (**4e**), 67% (91%[b])
R^1 = Bn (**5e**), 92%

R^1 = Ph (**4f**), 80%
R^1 = Bn (**5f**), 79%

R^1 = Ph (**4g**), 77%
R^1 = Bn (**5g**), 74%

R^1 = Ph (**4h**), 71%
R^1 = Bn (**5h**), 70%

R^1 = Ph (**4ia**), 20% R^1 = Ph (**4ib**), 46%
R^1 = Bn (**5ia**), 51% R^1 = Bn (**5ib**), 21%

R^1 = Ph (**4j**), 32%

4j1, 14%

4j2, 23%

4k1, 48%

4k2, 8%

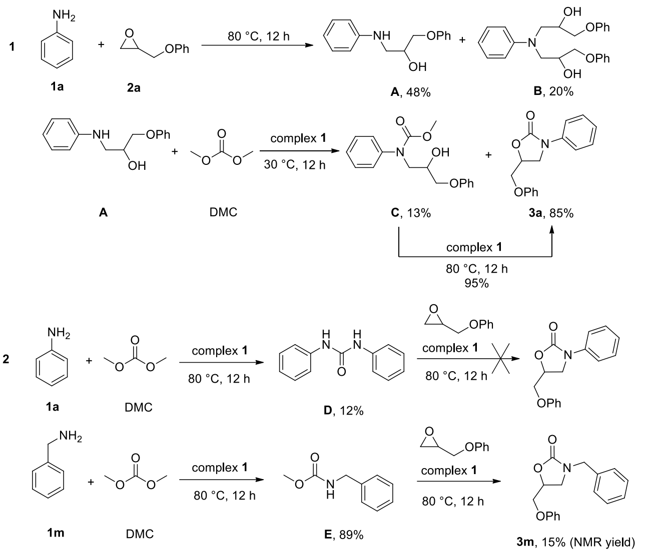
R^1 = Ph (**4k**), 36% (67%[c])

4l1, 94%

R^1 = Ph (**4l**), 0%

[a] Reaction conditions: amine (2 mmol), epoxide (1 mmol), dimethyl carbonate (2 mmol). R^1 = Ph: complex **1** (2 mol%); R^1 = Bn: complex **1** (4 mol%). 80 ℃, 12 h, isolated yield. [b] 4 mol% catalyst. [c] 8 mol% catalyst.

Control experiments were conducted to further understand the reaction mechanism (Scheme 1). 2-(phenoxymethyl)oxirane **2a** was treated with 1 equivalent of aniline in the absence of complex **1**, which generated amino alcohols **A** and **B** in 48% and 20% yields, respectively. The same results were obtained in the presence of 2 mol% complex **1** as well. Formation of **B** should be suppressed under template catalytic conditions due to presence of excess aniline. β-amino alcohols analogous to **A** (*i.e.*, compounds **4e1**, **4j1**, **4k1**, and **4l1**) were detected in reactions of other epoxides (*vide supra*), suggesting that they are intermediates of oxazolidinone formation.



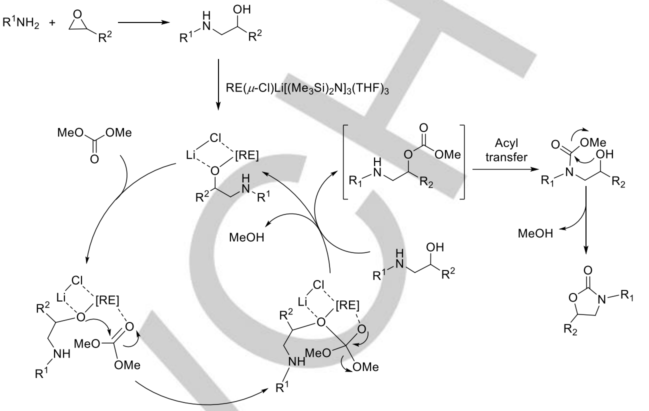
Scheme 1. Control Experiments to Produce Oxazolidinones.

At 30 °C, β-amino-alcohol **A** reacted with excess amount of DMC in the presence of complex **1**, and formed compound **3a** in 85% yield, along with 13% carbamate **C**. Intramolecular transesterification of **C** leads to quantitative formation of **3a** under template condition, suggesting **C** as an intermediate for **3a**.[6a-e]

This route is further proved by the stereochemistry of cyclohexene oxide reaction. Starting from *cis*-configured cyclohexene oxide, ring-opening of epoxides caused by nucleophilic aniline led to configuration inversion, forming *trans*-**4k1**. Subsequent amidation of **4k1** with DMC led to carbamate **4k2** formation, which underwent ring-closing to form oxazolidinone **4k**.

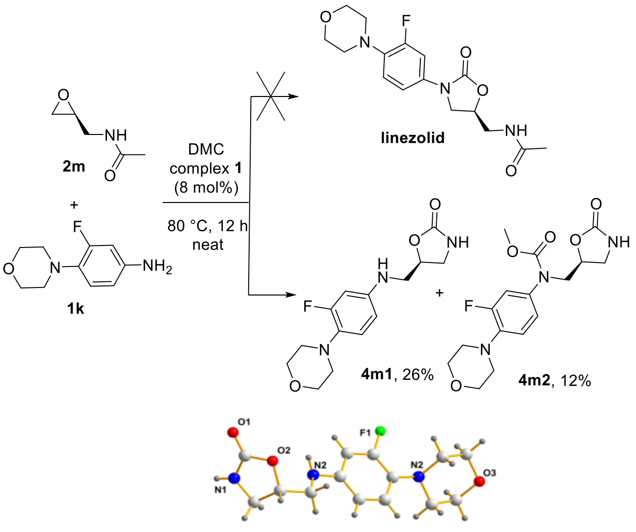
Another control reaction of aniline and DMC catalyzed by complex **1** afforded urea **D** in 12% yield, which did not react with 2-(phenoxymethyl)oxirane **2a**. On the other hand, benzyl amine was converted into carbamate **E** in 89% yield, which subsequently reacted with 2-(phenoxymethyl)oxirane **2a** and produced oxazolidinone **3m** in 15% yield determined by ^1H NMR spectroscopy.[6a-e]

Based on above-discussed findings, two plausible pathways are proposed. The formation of amino alcohol followed by reaction with DMC through amidation generating carbamate and subsequent intramolecular transesterification leads to oxazolidinone formation (Scheme 2).[3c-h] This procedure resembles the reaction of epoxides and carbamates.[6] The other pathway starts from formation of amides,[14] which generate carbamates that further react with epoxides to yield oxazolidinones.[6a-e] This might be a minor route that is only applicable to aliphatic amines (*vide supra*).



Scheme 2. Possible Pathway for the Three-Component Reaction.

With the multicomponent method in hand, we attempted to synthesize linezolid, which is a oxazolidinone-based antibiotic, from easily available starting materials (*S*)-*N*-(oxiran-2-ylmethyl)acetamide (**2m**) and 3-fluoro-4-(4-morpholinyl)aniline (**1k**).[15] Although under template conditions, **1k** reacted straightforwardly with 2-(phenoxymethyl)oxirane (**2a**) and generated oxazolidinone **3k** in 91% yield (Table 2), reaction with (*S*)-*N*-(oxiran-2-ylmethyl)acetamide (**2m**) did not yield linezolid, but generated oxazolidinones **4m1** and **4m2** (Scheme 3). Both compounds are characterized by NMR and MS techniques, and the identity of **4m1** is further confirmed by X-ray diffraction analysis. Apparently, C-N bond of amide group was cleaved, and ring-closure occurred preferentially to the NH side instead of aniline side.



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Scheme 3. Attempt to Synthesize Linezolid through Multicomponent Reaction.

Conclusions

In summary, we have developed a simple and highly practical rare-earth-metal-catalyzed multicomponent approach for the synthesis of oxazolidinones. Starting materials, *i.e.*, epoxides, carbonate, and amines, are all easily available, and substrate scope includes a wide range of aromatic and aliphatic amines, as well as mono-substituted epoxides. 47 examples of variously substituted oxazolidinones were obtained in 13-97% yields, demonstrating wide applicability of this method. Scope of disubstituted epoxides is limited, which requires further study. Preliminary mechanistic studies reveal that two possible pathways, *i.e.*, through reaction of β-amino-alcohols and DMC, or through reaction of amides with epoxides, give access to oxazolidinones. Study on rare-earth metal catalyzed atom-economic transformations is on-going in our laboratory.

Experimental Section

General procedure of three component reaction

Complex **1** (R^1 = Ph: 17.6 mg, 0.02 mmol; R^1 = Bn: 35.2 mg, 0.04 mmol), amines (2 mmol), epoxides (1 mmol), and DMC (0.17 mL, 2 mmol) were introduced into a 5 mL glass vial equipped with a stir bar in a glovebox, and heated at 80 ºC after 12 h reaction. The reaction mixture was purified by column chromatography using ethyl acetate/petroleum ether = 1/3-1/0, and the resulting oxazolidinone was characterized by ^{1}H and ^{13}C NMR spectroscopy and HR MS.

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Keywords: oxazolidinones • rare earth amides • multicomponent reactions

[1] a) D. J. Ager, I. Prakash, D. R. Schaad, *Aldrichimica Acta.* **1997**, *30*, 3; b) W. R. Roush, R. A. James, *Aust. J. Chem.* **2002**, *55*, 141.

[2] a) C. W. Ford, J. C. Hamel, D. Stapert, J. K. Moerman, D. K. Hutchinson, M. R. Barbachyn, G. E. Zurenko, *Trends Microbiol.* **1997**, *5*, 196; b) S. Cacchi, G. Fabrizi, A. Goggiamani, G. Zappia, *Org. Lett.* **2001**, *3*, 2539; c) G. E. Zurenko, J. K. Gibson, D. L. Shinabarger, P. A. Aristoff, C. W. Ford, W. G. Tarpley, *Curr. Opin. Pharmacol.* **2001**, *1*, 470; d) B. Mallesham, B. M. Rajesh, P. R. Reddy, D. Srinivas, S. Trehan, *Org. Lett.* **2003**, *5*, 963; e) A. Ali, G. S. K. K. Reddy, H. Cao, S. G. Anjum, M. N. L. Nalam, C. A. Schiffer, T. M. Rana, *J. Med. Chem.* **2006**, *49*, 7342.

[3] a) S. I. Fujita, H. Kanamaru, H. Senboku, M. Arai, *Int. J. Mol. Sci.* **2006**, *7*, 438; b) K. I. Tominaga, Y. Sasaki, *Synlett.* **2002**, *2*, 0307; c) S. R. Jagtapa, Y. P. Patila, S. Fujitab, M. Araib, B. M. Bhanagea, *Appl. Catal. A* **2008**, *341*, 133; d) S. Pulla, V. Unnikrishnan, P. Ramidi, S. Z. Sullivan, A. Ghosh, J. L. Dallas, P. Munshi, *J. Mol. Catal. A* **2011**, *338*, 33; e) R. Morales-Nava, M. Fernández-Zertuche, M. Ordóñez, *Molecules* **2011**, *16*, 8803; f) N. Caldwell, P. S. Campbell, C. Jamieson, F. Potjewyd, I. Simpson, A. J. B. Watson, *J. Org. Chem.* **2014**, *79*, 9347; g) Y. Zhang, Y. Zhang, Y. Ren, O. Ramström, *J. Mol. Catal. B: Enzym.* **2015**, *122*, 29; h) Y. Zhang, Y. Zhang, S. Xie, M. Yan, O. Ramström, *Catal. Commun.* **2016**, *82*, 11.

[4] a) G. P. Speranza, W. J. Peppel, *J. Org. Chem.* **1958**, *23*, 1922; b) M. Fujiwara, A. Baba, Y. Tomohisa, H. Matsuda, *Chem. Lett.* **1986**, 1963; c) C. Larksarp, H. Alper, *J. Am. Chem. Soc.* **1997**, *119*, 3709; d) T. Baronsky, C. Beattie, R. W. Harrington, R. Irfan, M. North, J. G. Osende, C. Young, *ACS. Catal.* **2013**, *3*, 790; e) R. L. Paddock, D. Adhikari, R. L. Lord, M. H. Baik, S. T. Nguyen, *Chem. Commun.* **2014**, *50*, 15187; f) Y. Toda, S. Gomyou, S. Tanaka, Y. Komiyama, A. Kikuchi, H. Suga, *Org. Lett.* **2017**, *19*, 5786.

[5] a) M. Feroci, M. Orsini, G. Sotgiu, L. Rossi, A. Inesi, *J. Org. Chem.* **2005**, *70*, 7795; b) T. Ishida, R. Kobayashi, T. Yamada, *Org. Lett.* **2014**, *16*, 2430; c) J. Hu, J. Ma, Q. Zhu, Z. Zhang, C. Wu, B. Han, *Angew. Chem. Int. Ed.* **2015**, *54*, 5399; d) Z. Chang, X. Jing, C. He, X. Liu, C. Duan, *ACS Catal.* **2018**, *8*, 1384; e) A. W. Miller, S. T. Nguyen, *Org. Lett.* **2004**, *6*, 2301; f) M. T. Hancock, A. R. Pinhas, *Tetrahedron Lett.* **2003**, *44*, 5457; g) Y. Wu, L. He, Y. Du, J. Wang, C. Miao, W. Li, *Tetrahedron* **2009**, *65*, 6204; h) R. A. Watile, D. B. Bagal, K. M. Deshmukh, K. P. Dhake, B. M. Bhanage, *J. Mol. Catal. A* **2011**, *351*, 196.

[6] a) G. Bartoli, M. Bosco, A. Carlone, M. Locatelli, P. Melchiorre, L. Sambri, *Org. Lett.* **2005**, *7*, 1983; b) J. Shang, S. Liu, L. Lu, X. Ma, Y. He, Y. Deng, *Catal. Commun.* **2012**, *28*, 13; c) V. Laserna, W. Guo, A. K. Kleij, *Adv. Synth. Catal.* **2015**, *357*, 2849; d) J. Shang, Z. Li, C. Su, Y. Guo, Y. Deng, *RSC Adv.* **2015**, *5*, 71765; e) E. H. M. Elageed, B. Chen, B. Wang, Y. Zhang, S. Wu, X. Liu, G. Gao, *Eur. J. Org. Chem.* **2016**, 3650.

[7] a) B. Wang, E. H. M. Elageed, D. Zhang, S. Yang, S. Wu, G. Zhang, G. Gao, *ChemCatChem* **2014**, *6*, 278; b) Y. Song, C. Cheng, H. Jing, *Chem. Eur. J.* **2014**, *20*, 12894; c) B. Wang, Z. Luo, E. H. M. Elageed, S. Wu, Y. Zhang, X. Wu, F. Xia, G. Zhang, G. Gao, *ChemCatChem* **2016**, *8*, 830; d) B. Xu, P. Wang, M. Lv, D. Yuan, Y. Yao, *ChemCatChem* **2016**, *8*, 2466; e) M. Lv, P. Wang, D. Yuan, Y. Yao, *ChemCatChem* **2017**, *9*, 4451. f) U. R. Seo, Y. K. Chung, Green Chem. 2017, 19, 803; g) S. M. Sadeghzadeh, R. Zhiani, S. Emrani, *Catal. Lett.* **2018**, *148*, 119; h) S. M. Sadeghzadeh, R. Zhiani, M. Moradi, *ChemistrySelect* **2018**, *3*, 3516.

[8] a) T. Niemi, J.E. Perea-Buceta, I. Fernández, O.M. Hiltunen, V. Salo, S. Rautiainen, M. T. Räisänen, T. Repo, *Chem. Eur. J.* **2016**, *22*, 10355; b) C. Mei, Y. Zhao, Q. Chen, C. Cao, G. Pang, Y. Shi, *ChemCatChem* **2018**, *10*, 3057.

[9] a) R. Schwesinger, *Chimia* **1985**, *39*, 269; b) R. Schwesinger, H. Schlemper, *Angew. Chem., Int. Ed.* **1987**, *26*, 1167; c) C. G. McPherson, A. K. Cooper, A. Bubliauskas, P. Mulrainey, C. Jamieson, A. J. B. Watson, *Org. Lett.* **2017**, *19*, 6736. (BEMP: tert-butylimino-2-diethylamino-1,3-dimethylperhydro-1,3,2-diazaphosphorine).

[10] a) H. Sasai, T. Suzuki, N. Itoh, K. Tanaka, T. Date, K. Okamura, M. Shibasaki, *J. Am. Chem. Soc.* **1993**, *115*, 10372; b) N. Yoshikawa, Y. M. A. Yamada, J. Das, H. Sasai, M. Shibasaki, *J. Am. Chem. Soc.* **1999**, *121*, 4168; c) L. Zhang, S. Wang, E. Sheng, S. Zhou, *Green Chem.* **2005**, *7*, 683.

[11] a) Q. Qian, Y. Tan, B. Zhao, T. Feng, Q. Shen, Y. Yao, *Org. Lett.* **2014**, *16*, 4516; b) C. Zeng, D. Yuan, B. Zhao, Y. Yao, *Org. Lett.* **2015**, *17*, 2242.

[12] a) Y. Lee, J. Choi, H. Kim, *Org. Lett.* **2018**, *20*, 5036; b) M. Selva, M. Fabris, *Green Chem.* **2009**, *11*, 1161; c) T. Niemi, I. Fernández, B. Steadman, J. K. Mannistoa, T. Repo, *Chem. Commun.* **2018**, *54*, 3166.

[13] a) A. Baba, K. Seki, H. Matsuda, *J. Org. Chem.* **1991**, *56*, 2684; b) G. Sekar, V. K. Singh, *J. Org. Chem.* **1999**, *64*, 287.

[14] a) N. Nagaraju, G. Kuriakose, *Green Chem.* **2016**, *4*, 269; b) A. Ying, H. Hou, S. Liu, G. Chen, J. Yang, S. Xu, *ACS Sustainable Chem. Eng.* **2016**, *4*, 625; c) C. Han, J. A. Porco, Jr, *Org. Lett.* **2007**, *9*, 1517; d) S. Kumar, S. L. Jain, *Dalton Trans.* **2013**, *42*, 15214; e) P. Wang, Y. Fei, Q. Li, Y. Deng, *Green Chem.* **2016**, *18*, 6681; f) R. Zeng, L. Bao, H. Sheng, L. Sun, M. Chen, Y. Feng, M. Zhu, *RSC Adv.* **2016**, *6*, 78576.

[15] a) W. R. Perrault, B. A. Pearlman, D. B. Godrej, A. Jeganathan, K. Yamagata, *Org. Process Res. Dev.* **2003**, *7*, 533; b) A. P. Piccionello, P. Pierro, A. Accardo, S. Buscemi, A. Pace, *RSC Adv.* **2013**, *3*, 24946.

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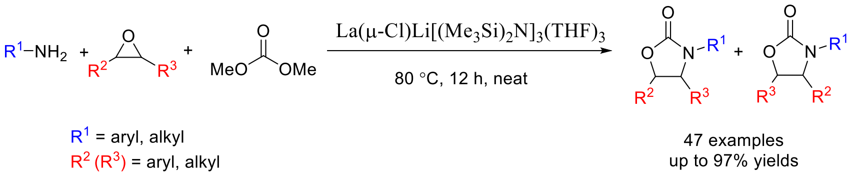

A simple rare-earth-metal-catalyzed multicomponent approach to oxazolidinone synthesis is developed from easily available materials, *i.e.*, epoxides, carbonate, and amines. Substrate scope includes a wide range of aromatic and aliphatic amines, as well as mono- and di-substituted epoxides. Preliminary mechanistic studies suggest β-amino alcohols or amides as intermediates.

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