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Highly diastereoselective conjugate additions of monoorganocopper reagents to chiral imides

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Abstract—Stereoselective conjugate additions to chiral *N*-enoyl amides employing various monoorganocuprate reagents, Li[RCuI], are described. The presence of TMSI in the addition of Li[RCuI] in THF provided the highest stereoselectivities. Reversed major diastereomeric ratios were obtained employing Li[RCuI] in ether or conventional copper-promoted Grignard reagents. The results presented support the favored *anti-s-cis* conformation of the substrates using Li[RCuI]/TMSI in THF, while the copper-promoted Grignard reagents or the Li[RCuI] reagents in ether favor the opposite *syn-s-cis* conformation. Influence of lithium ions on the stereoselective conjugate addition of the monoorganocuprate reagent, Li[BuCuI], has been investigated and two different mechanistic pathways are presented. The results show that iodotrimethylsilane (TMSI) is crucial for the asymmetric conjugate addition of the copper reagent, but only in THF or when 12-crown-4 is used. The reaction is thought not to involve any halosilane in any critical steps in the organocopper mechanisms conducted in ether. The $(CuI)_4(SMe_2)_3$ complex precursor plays an instrumental role for the conjugate addition using monoorganocopper reagents.

1. Introduction

Organocopper reagents are among the most versatile reagents available for conjugate addition reactions.[1] Applications of organocopper chemistry began nearly four decades ago when House[2] demonstrated the very useful Gilman reagents, LiR_2Cu, in conjugate addition reactions. However, the major disadvantage with the LiR_2Cu type reagent is that one has to employ at least 2 equiv. of the lithium reagent for each equivalent of copper(I) source, which would become a serious dilemma if indispensable R groups are employed. The monoorganocopper reagents, depicted either as RCu·LiX or Li[RCuX],[2b] possess an excellent economy of group transfer. However, their inherent lower solubility and reactivity have limited their widespread use as reliable reagents in conjugate addition reactions. These problems can sometimes be solved by taking advantage of Lewis acids[3] or non-transferable ligands,[4] in the conjugate addition process. Chlorotrimethylsilane (TMSCl) is probably the most common additive employed with Gilman type reagents.[5]

Several contradicting theories have appeared regarding the precise role of TMSCl in the addition of LiR_2CuLi,[5f–u] but it seems most likely that TMSCl is favoring a rate limiting silylation of an intermediate copper π-complex.[5d,e] This mechanistic insight regarding the organocuprate in conjugate addition was supported by determination of kinetic isotope effects for $Li[Bu_2Cu]$ promoted by TMSCl to enones in ether and THF.[5v] Because of the uncertainty of many variables in the organocopper reactions (e.g. cuprate structures, solvent, additives, reaction conditions, substrate as well as the cuprate cluster at each stage of the reaction pathway), a detailed mechanistic explanation has not yet emerged. Nor could an α-cuprioketone be neglected as a favored reaction intermediate.[6] It is generally accepted that the initial lithium–carbonyl coordination is a critical initial feature in the conjugate addition in the absence of additives, which also seems to be a sufficient activator for highly reactive α,β-unsaturated systems. On the other hand, butylcopper prepared from BuLi and CuI in ether, washed free from LiI at −78 °C, has been reported to undergo conjugate addition to a chiral enoate in the presence of iodotrimethylsilane (TMSI).[7c] Thus, in absence of lithium, there is evidence that powerful electrophiles, e.g. trimethylsilyl triflate[7d] and TMSI,[7] can promote the conjugate addition of butylcopper.

Chiral 2-oxazolidinones[8] have also been used as efficient chiral auxiliaries for copper-promoted asymmetric conjugate additions of Grignard reagents[9] and zirconium reagents.[10] Recently, we reported stereoselectivities as high as 96% diastereomeric excess (de) employing TMSI as an additive using Li[RCuI] in asymmetric conjugate

Keywords: Organocopper; Conjugate addition; 1,4-Addition; TMSI; Asymmetric addition.
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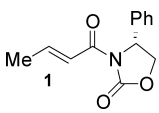
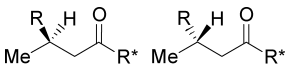
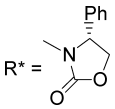
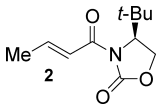
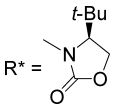
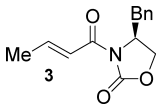
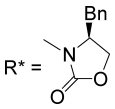
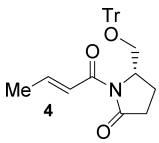
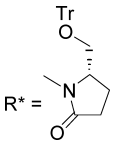
Table 1. Asymmetric conjugate additions to various *N*-crotonyl substituted chiral auxiliaries (**1**–**4**)

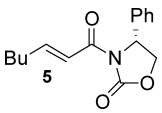
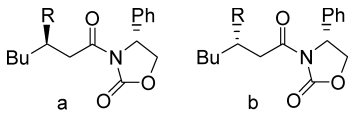
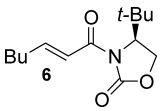
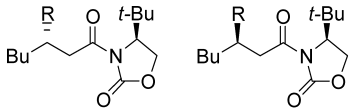
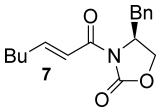
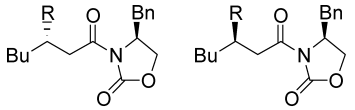
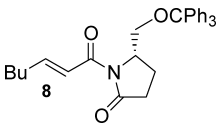
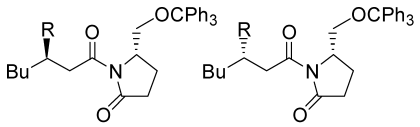
Substrate	Entry	Cu(I)[a]	Reagent	Additives(s)[b]	Ratio(a:b)	Yield[c]	Product (a:b)	Reference
	1	A	Li[BuCuI]/THF	TMSI	**15**; R=Bu; 98:2 (**15***S*:**15***R*)	83		9f,g
	2	A	Li[BuCuI]/THF	-	**15**; R=Bu; 24:76 (**15***S*:**15***R*)	60(30)		9g
	3	A	Li[BuCuI]/THF	TMSCI	**15**; R=Bu; 14:86 (**15***S*:**15***R*)	12(85)		9g
	4	A	Li[BuCuI]/Et_2O	TMSI	**15**; R=Bu; 6:94 (**15***S*:**15***R*)	90		9g
	5	A	Li[BuCuI]/Et_2O	-	**15**; R=Bu; 6:94 (**15***S*:**15***R*)	90		9g
	6	A	Li[BuCuI]/Et_2O (2 h)	TMSI	**15**; R=Bu; 6:94 (**15***S*:**15***R*)	75(20)		9g
	7	A	Li[BuCuI]/Et_2O (2 h)	-	**15**; R=Bu; 6:94 (**15***S*:**15***R*)	75(20)		9g
	8	A	Li[BuCuI]/Et_2O	TMSI/12 4[d]	**15**; R=Bu; 72:28 (**15***S*:**15***R*)	80		9g
	9	A	Li[BuCuI]/Et_2O	TMSI/12 4[e]	**15**; R=Bu; 96:4 (**15***S*:**15***R*)	80		9g
	10	A	Li[BuCuI]/Et_2O	12 4[e]	**15**; R=Bu; -	0(90)		9g
	11	A	Li[BuCuI]/THF	$MgBr_2$[f]	**15**; R=Bu; 9:91 (**15***S*:**15***R*)	77		9f
	12	B[g]	Li[BuCuI]/THF	TMSI	**15**; R=Bu; 90:10 (**15***S*:**15***R*)	50(45)		9g
	13	B	Li[BuCuI]/THF	-	**15**; R=Bu; 44:56 (**15***S*:**15***R*)	12(85)		9g
	14	B	Li[BuCuI]/THF	TMSI	**15**; R=Bu; -	0(95)		9g
	15	A	Li[BuCuI]LiI/THF	TMSCI	15; R=Bu; 69:31 (**15***S*:**15***R*)	55(40)		9g
	16	A	Li[BuCuI]LiI/Et_2O	TMSCI	**15**; R=Bu; 45:55 (**15***S*:**15***R*)	85		9g
	17	A	Li[PuCuI]/THF	TMSI	**16**; R=Ph; 96:4 (**16***R*:**16***S*)	83		9f
	18	A	Li[PuCuI]/THF	-	**16**; R=Ph; 10:90 (**16***R*:**16***S*)	81		
	19	A	PhMgCI/CuI[h]/THF	-	**16**; R=Ph; 5:95 (**16***R*:**16***S*)	74		9f
	20	A	PhMgCI/CuI[h]/THF	TMSI	**16**; R=Ph; 5:95 (**16***R*:**16***S*)	51(40)		9f
	21	A	Li[BuCuI]/THF	TMSI	**17**; R=Bu; 93:7 (**17***R*:**17***S*)	80		
	22	A[i]	Li[BuCuI]/THF	TMSI	**17**; R=Bu; 93:7 (**17***R*:**17***S*)	77		
	23	A	BuMgBr/CuI[h]/THF	-	**17**; R=Bu; 9:91 (**17***R*:**17***S*)	75		
	24	A	Li[PuCuI]/THF	TMSI	**18**; R=Ph; 95:5 (**18***S*:**18***R*)	75		
	25	A	Li[BuCuI]/THF	TMSI	**19**; R=Bu; 85:15 (**19***R*:**19***S*)	98		9f
	26	A	Li[BuCuI]/THF	BF_3OEt_2	**19**; R=Bu; 80:20 (**19***R*:**19***S*)	14(85)		
	27	A	Li[BuCuI]/THF	$MgBr_2$[f]	**19**; R=Bu; 50:50 (**19***R*:**19***S*)	71		9f
	28	A	Li[PuCuI]/THF	TMSI	**20**; R=Ph; 87:13 (**20***S*:**20***R*)	86		9f
	29	A	PhMgCI/CuI[h]	-	**20**; R=Ph; 45:55 (**20***S*:**20***R*)	80		9f
	30	A	Li[*t*-BuCuI]/THF	TMSI	**21**; R=*t*-Bu; 87:13 (**21***S*:**21***R*)[j]	85		9f
	31	A	Li[BuCuI]/THF	TMSI	**22**; R=Bu; 94:6 (**22***S*:**22***R*)	97		7d
	32	A	Li[BuCuI]/LiI[k]/THF	TMSI	**22**; R=Bu; 93:7 (**22***S*:**22***R*)	97		
	33	A	Li[BuCuI]/THF	BF_3OEt_2	**22**; R=Bu; -	0(95)		
	34	A	BuMgBr/CuI[h]/THF	TMSI	**22**; R=Bu; 4:96 (**22***S*:**22***R*)	92		
	35	A	BuMgBr/CuI[l]/THF	TMSI	**22**; R=Bu; 7:93 (**22***S*:**22***R*)	47(50)		
	36	A	Li[PuCuI]/THF	TMSI	**23**; R=Ph; 96:4 (**23***R*:**23***S*)	94		7d
	37	A	Li[*t*-BuCuI]/THF	TMSI	**24**; R=*t*-Bu; 89:11 (**24***R*:**24***S*)	90[m]		
	38	A	Li[Bu_2Cu]LiI/Et_2O	TMSCI	**22**; R=Bu; 45:55 (**22***S*:**22***R*)	63		
	39	A	Li[Bu_2Cu]LiI/THF	TMSCI	**22**; R=Bu; 15:85 (**22***S*:**22***R*)	15		
	40	A	Li[Ph_2Cu]LiI/THF	TMSCI	**22**; R=Ph; 10:90 (**22***S*:**22***R*)	94		

[a] 1.4–1.5 equiv. of 'RCu' vs substrate. Reactions quenched after 4 h at −78 °C. A=CuI purified via DMS and used as the $(CuI)_4(DMS)_3$ complex. B=99.999% purity grade CuI.
[b] 1.0 equiv. additive vs copper reagent.
[c] Based on isolated and purified material (a+b). Recovered substrate in brackets.
[d] 1.0 equiv. 12-crown-4 vs lithium.
[e] 2.0 equiv. 12-crown-4 vs lithium.
[f] Precomplexed $MgBr_2{\cdot}OEt_2$ (1 equiv.) and imide **3** at +20 °C.
[g] 0.75 equiv. DMS added to CuI.
[h] CuI·0.75DMS (1 equiv.) vs RMgBr.
[i] $(CuI)_4(i\text{-}Pr_2S)_3$ complex.
[j] *R*/*S* assignments based on X-ray structure of **21a**(**21***S*).
[k] 9 equiv. LiI added.
[l] 10 mol% CuI·0.75DMS vs BuMgBr.
[m] *R*/*S* assignments based on analogy.

additions to enantiomerically pure *N*-enoyl 2-oxazolidinones.[9f,g] We also described the efficiency of $MgBr_2$ as an additive to alter the availability of the possible π-faces in asymmetric conjugate addition reactions to these substrates. In an associated study, we reported the influence of dimethyl sulfide (DMS) as a key component for obtaining outstanding yields and high levels of stereoselectivity in the 1,4-addition of monosilylcopper reagents.[11]

We now report a wide variety of copper-promoted asymmetric conjugate addition reactions utilizing a number of chiral *N*-enoyl substituted amides. Several auxiliaries have been scrutinized in order to expand the scope of the asymmetric conjugate additions employing the Li[RCuI]/TMSI system. The monoorganocopper reagent prepared from the CuI·0.75DMS precursor complex is extraordinarily useful in conjugate addition reactions. DMS remaining from purified CuI, plays a decisive role in obtaining very high yields and surprisingly high levels of stereoselectivity. Due to the drastic solvent dependence on the conjugate addition of Li[RCuI], two significantly different mechanistic models are presented.

Table 2. Asymmetric conjugate additions to various *N*-heptenoyl substituted chiral auxiliaries (**5**–**8**)

Entry	Reagent(s)[a] (RCu)	Substrate product(s) (a:b)	Product(s) (a:b)	Ratio (**a**:**b**)	Yield[b]	Reference
41	Li[PhCuI]/TMSI			**25**; R=Ph; 97:3 (**25***R*:**25***S*)	83	9f
42	Li[PhCuI]/TMSI			**15**; R=Me; 91:9 (**15***R*:**15***S*)	84	9f
43	Li[PhCuI]/TMSI			**26**; R=Ph; 91:9 (**26***S*:**26***R*)	90	
44	Li[MeCuI]/TMSI			**17**; R=Me; 93:7 (**17***S*:**17***R*)	71	
45	Li[PhCuI]/TMSI			**27**; R=Ph; 88:12 (**27***S*:**27**R	87	9f
46	Li[MeCuI]/TMSI			**19**; R=Me; 82:18 (**19***S*:**19***R*)	86	9f
47	Li[Me_2CuI]/TMSI			**19**; R=Me; -	0(80)	
48	Li[MeCuI]/TMSI			**22**; R=Me; 97:3 (**22***R*:**22***S*)	91	7d
49	Li[MeCuI]/BF_3OEt_2			**22**; R=Me; -	0(95)	
50	Li[PhCuI]/TMSI			**28**; R=Ph; 94:6 (**28***R*:**28***S*)	92	7d

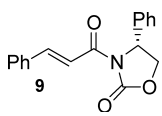
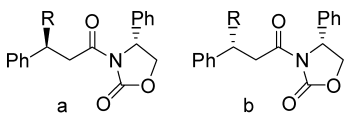
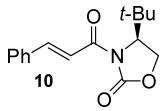
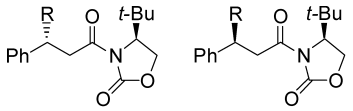
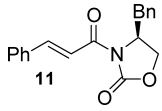
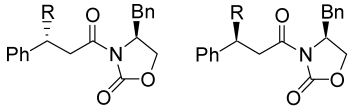
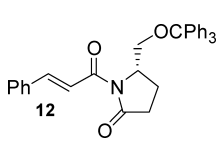
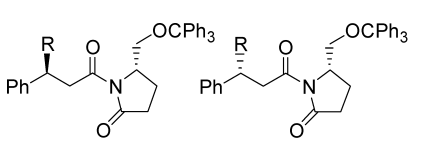
[a] 1.4–1.5 equiv. of 'RCu' vs substrate. 'RCu'/additive ratio=1:1. Solvent: THF. Reactions quenched after 4 h at −78 °C. Purified CuI used as the CuI·0.75DMS complex.
[b] Based on purified and isolated material (a+b). Recovered substrate in brackets.

2. Results and discussion

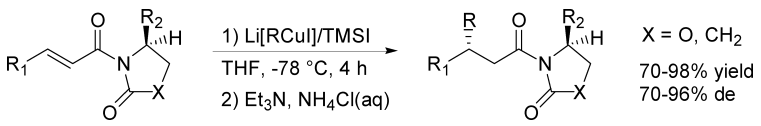
This study focuses on conjugate additions of organocopper reagents to various optically active *N*-enoyl 2-oxazolidinones and 2-pyrrolidinones. The TMSI promoted conjugate addition of Li[RCuI] has been used with considerable success to many α,β-unsaturated systems, and we now show the versatility of this protocol when using a number of chiral starting materials. The TMSI-promoted addition of Li[RCuI] was compared in terms of yield and diastereomeric ratio to a number of very common organocopper reagents (e.g., R_2CuLi/TMSCl, RMgX/CuI, or RCu/BF_3) in asymmetric conjugate addition (Tables 1–3). Employing the monoorganocuprate reagent, Li[RCuI], in the presence of TMSI was undoubtedly the most successful system, giving highest yields and highest diastereomeric ratios (Scheme 1).

The lithium monoorganocuprate reagents, Li[RCuI], were prepared from 1 equiv. of the appropriate organolithium

Table 3. Asymmetric conjugate additions to various *N*-cinnamoyl substituted chiral auxiliaries (**9**–**12**)

Entry	Reagent(s)[a] (RCu)	Substrate	Product(s) (a:b)	Ratio (**a:b**)	Yield[b]	Reference
51	Li[MeCuI]/TMSI			**16**; R=Me; 92:8 (**16***S*:**16***R*)	80	9f
52	Li[MeCuI]/TMSI			**25**; R=Bu; 92:8 (**25***S*:**25***R*)	96	9f
53	Li[MeCuI]/TMSI			**18**; R=Me; 95:5 (**18***R*:**18***S*)	80	
54	Li[MeCuI]/TMSI			**26**; R=Bu; 91:9 (**26***R*:**26***S*)	83	
55	Li[MeCuI]/TMSI			**27**; R=Bu; 90:10 (**27***R*:**27***S*)	91	9f
56	Li[MeCuI]/TMSI			**20**; R=Me; 89:14 (**20***R*:**20***S*)	83	9f
57	$LiMe_2Cu$/TMSCl			**20**; R=Me; -	0(80)	
58	$LiMe_2Cu$/TMSCl[c]			**20**; R=Me; -	20(70)	
59	Li[MeCuI]/TMSI			**23**; R=Me; 94:6 (**23***S*:**23***R*)	99	7d
60	Li[BuCuI]/TMSI			**28**; R=Bu; 96:4 (**28***S*:**28***R*)	93	7d
61	Li[BuCuI]/TMSOTf			**28**; R=Bu; 92:8 (**28***S*:**28***R*)	93	7d
62	Li[BuCuI]/TMSI[d]			**28**; R=Bu; 91:9 (**28***S*:**28***R*)	59(35)	

[a] 2.0 equiv. of 'RCu' vs substrate. 'RCu'/additive ratio=1:1. Solvent: THF. Reactions quenched after 4 h at −78 °C. Purified CuI used as the CuI·0.75DMS complex.
[b] Based on purified and isolated material (a+b). Recovered substrate in brackets.
[c] Ether as solvent.
[d] 1.4 equiv. Li[BuCuI]/TMSI vs **12**.



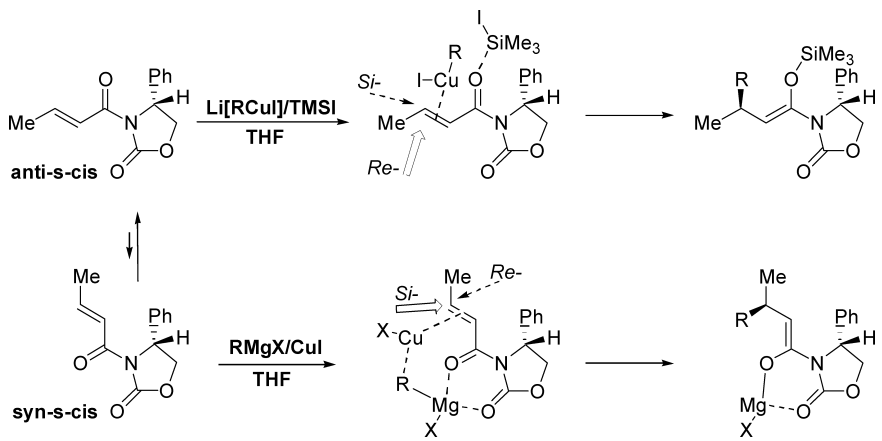
Scheme 1.

reagent and 1.1 equiv. of DMS purified CuI.[12] The initial CuI–DMS complex isolated is unstable, but after removal of DMS under reduced pressure, the final stoichiometry {[CuI]$_4$[DMS]$_3$}, remains essentially the same.[13] The CuI purified via DMS is the Cu(I) precursor of choice because of the high yields as well as high stereoselectivities in the conjugate additions to chiral crotonates (Table 1). Thus, employing phenylglycine-derived imide (**1**) in a conjugate addition reaction of Li[BuCuI]/TMSI, obtained from BuLi and CuI·0.75DMS, gave 96% de of product **15***S* (entry 1). It was instrumental to use the purified CuI·0.75DMS complex[14] instead of the high purity grade CuI, with or without the presence of DMS. Entries 12–14 demonstrate the effect of DMS, either by precomplexation[15a] or subsequent addition,[15b] on the solubility and reactivity of the copper reagent. Efforts to alter the stereoselectivity utilizing the bulkier diisopropyl sulfide ligand,[16] CuI·0.75S (*i*-Pr)$_2$,[17] resulted in a stereoselectivity of product **17** identical to that found using the CuI·0.75DMS complex (entries 21, 22).

Typically, 1.4 equiv. of the Li[RCuI]/TMSI reagent system was employed, but for the less reactive cinnamates 2 equiv. of the copper reagent generally was necessary (Table 3). The diasteromeric ratios of the products were measured on clearly resolved ^{1}H NMR signals of the crude reaction products. The absolute configuration at the β-carbon was established by optical rotation of the optically active carboxylic acids[18] or alcohols[19] obtained after chemical removal of the chiral auxiliaries. Phenylglycine- and pyrrolidinone-derived auxilaries were the most efficient for the conjugate additions employing the Li[RCuI]/TMSI as reagent systems. The phenylglycine-derived oxazolidinone has previously been found to be an excellent auxiliary for conjugate additions of copper-promoted Grignard reagents[9a] and zirconium reagents.[10] In comparison, the *tert*-leucine- and valine-derived[9f] oxazolidinone auxiliaries were found to yield slightly lower stereoselectivities (~90% de) while the phenylalanine-derived auxiliary gave modest selectivities (~70% de) under identical reaction conditions.

The presence of TMSI is crucial for high stereoselectivity and yield, but only in THF. Avoiding TMSI in the addition of Li[BuCuI] in THF not only decreased the rate of the reaction, but also provided excess of diastereomer **15***R* (entry 2). This same major diasteromer was obtained in much greater excess and yield in ether (entry 4). As the initial metal-carbonyl interaction seems stronger in ether compared to THF, the imide is allowed to more readily undergo a conjugate addition via the proposed metal chelated *syn-s-cis* conformation rather than the *anti-s-cis* conformer (Scheme 2).[9f]

Absence of TMSI during the conjugate addition of Li[BuCuI] seems to favor the substrate reacting in a *syn*-carbonyl *s-cis* conformation, where a weak chelation effect of the lithium cation may play a role in providing excess of the opposite diastereomer (**15***R*). Addition of scavenger chelating agents to the organocopper reagent such as $MgBr_2$ or LiI (entry 32) did not initially appear to affect the de or the yield for the TMSI-activated additions of Li[RCuI].[9f] The 'forced' complexation between $MgBr_2$·OEt_2 and substrates, on the other hand, has a remarkable effect on the conjugate addition of Li[BuCuI] (entries 11, 27). The precomplexed $MgBr_2$/imide and the Grignard reagents seem to react with the imide adopting the *syn-s-cis* conformation. Thus, conducting the 1,4-addition reactions employing the copper reagents in the presence of magnesium, either in the form of a Grignard reagent or as a 'forced' precomplexed $MgBr_2$·OEt_2/imide, provided excess of the opposite major diastereomer than the Li[RCuI]/TMSI reagent system in THF. The Li[RCuI]/TMSI reagents provide higher levels of stereoselectivity than the corresponding copper-promoted Grignard reagents. This is particularly the case for the phenylalanine-derived auxiliary (**3**), where a nearly complete loss of stereoselectivity was obtained using a copper-promoted addition of PhMgCl (entry 29) while the conjugate addition of Li[PhCuI]/TMSI provided 74% de of diastereomer **20***S* (entry 28). The copper-promoted Grignard reagent additions were faster than the corresponding



Scheme 2.

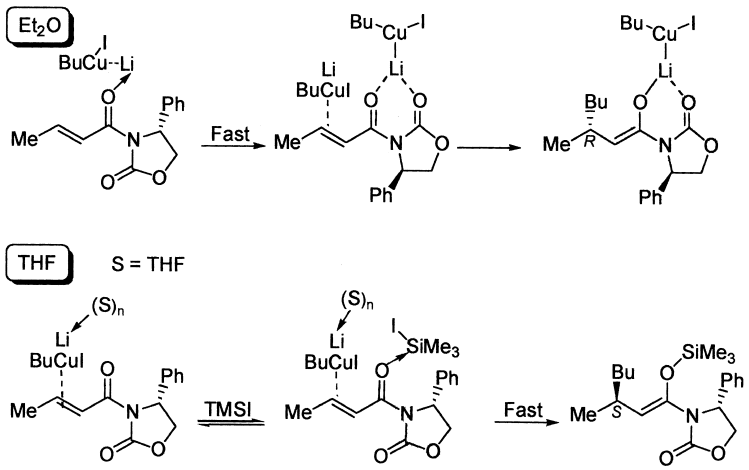
additions employing Li[RCuI]/TMSI in THF. Thus, quenching a Li[PhCuI]/TMSI reaction at −78 °C after 2 h confirmed 50% consumption of substrate **1** whereas the addition of PhMgCl/CuI was complete within 2 h at −78 °C. A relatively slow reaction at −78 °C is most likely a crucial factor in obtaining high stereoselectivity. In comparison, the TMSI-promoted conjugate additions of Li[MeCuI] at −78 °C to imides **5** and **9** provided 82–84% de of products **15** and **16**, whereas the analogous MeMgBr/CuBr addition to the same cinnamate **9** has been reported to give only 48% de.[9a] The same major stereoisomer was obtained when TMSI (entry 25) was replaced with $BF_3{\cdot}OEt_2$ (entry 26), but the yield was only 14% under identical reaction conditions (4 h, −78 °C). Thus, the Li[PhCuI]/TMSI system is far more efficient in conjugate addition reactions than the copper-promoted Grignard reagents or Li[RCuI]/BF_3 in terms of yield and stereoselectivity to the imides (entry 33).

Two significantly distinct solvent-dependent reaction pathways were observed for the conjugate addition of Li[BuCuI]/TMSI to *N*-crotonyl-2-oxazolidinone (**1**). Conducting the addition to (**1**) in THF afforded 96% de of product **15***S* (entry 1). On the other hand, conducting the conjugate addition in ether and employing the same copper reagent (entry 4) gave 88% de of the opposite diastereomer (**15***R*) in 90% yield. Due to the dramatic switch in diastereomeric ratio, several mechanistic questions for the iodosilane promoted conjugate addition of the monoorganocuprate reagents become apparent. The lithium ion is proposed to initially coordinate one or both carbonyl groups in the imide when conducting the reaction in ether, while a rapid silylation by TMSI of the copper π-complex is more likely the case when the reaction is conducted in THF.

Much to our surprise, we found that the presence of TMSI for the addition of Li[BuCuI] to **1** in ether was unnecessary (entry 5).[9g] The results, such as reaction rates, chemical yields and stereoselectivities, were identical whether or not TMSI was present in the conjugate addition of Li[BuCuI] to **1** in ether (entry 6). By interrupting the Li[BuCuI] addition reactions after 2 h instead of the standard 4 h reaction time, an identical chemical yield as well as stereoselectivity of **15***R* was obtained with or without the presence of TMSI (entry 7). Employing 1 equiv. of 12-crown-4 relative to Li[BuCuI]/TMSI in ether increased the influence of the iodosilane as the silylating agent due to the crown ether–lithium complexation (entry 8). Increasing the amount of crown ether to 2 equiv. resulted in an increased stereoselectivity in favor of product **15***S* (entry 9). 12-Crown-4 Gilman type reagents have been characterized by crystallography, where it was shown that each lithium ion is coordinated to two 12-crown-4 molecules.[20] Although the iodosilane is considered highly electrophilic,[21] we propose that the lithium–carbonyl coordination in ether is kinetically favored over the TMSI-carbonyl interaction. Our results reported show that TMSI appears to coordinate very favorably to the carbonyl group in THF or in the presence of 12-crown-4.[22] When Li[BuCuI] is added to **1** in the absence of TMSI, either in THF (entry 2) or in the presence of 2 equiv. of 12-crown-4 (entry 10), the initial lithium carbonyl interaction decreases, as shown by the significant drop in yield.

Scheme 3 depicts the different proposed mechanisms of the conjugate addition reaction conducted in THF relative to ether that rationalize the dramatic change in stereoselectivity. TMSI is proposed to rapidly silylate an initial copper π-complex in THF, thus allowing the copper reagent to add to **1** via the most available π-face of the *s-cis* enone with the imide carbonyls adopting an *anti* non-chelated conformation. The rapid silylation of an initial copper π-complex has not only been proposed for the Me_2CuLi/TMSCl[5d,e,v] combination but also for Li[BuCuI]/TMSI in additions to cyclohexenone,[23] a process which is reported here to be favored only in THF.[24] However, in ether, a lithium species is believed to chelate the carbonyl groups preceding the formation of the copper π-complex,[25,26] therefore allowing the addition to occur with the most available π-face of the imide in an *s-cis* conformation, yielding excess of the other diastereomer (**15***R*). Although since formation of an α-cuprioketone[27] has been reported for Gilman type reagents as a favored intermediate, it can not be neglected as one possible intermediate also for the Li[BuCuI] reagent. The nature of the monoorganocopper species forming the π-complex[28] depicted is unknown, but there is the possibility for dimer[29] and higher oligomer[30] formations. Employing 1 equiv. TMSCl relative to lithium has a retarding effect on the conjugate addition of Li[BuCuI] (entry 3). Compared to the more electrophilic TMSI (a softer iodide), TMSCl (a harder chloride) is proposed to inhibit the reactivity of the Li[BuCuI] reagent, observed as a considerable drop in yield, either via a chlorine–copper or chlorine–lithium interaction. The rate of the conjugate addition was higher in the absence of TMSCl (entry 2). As expected, employing 1 equiv. of TMSCl in combination with the more reactive Gilman reagent, Li[Bu_2Cu]LiI showed a moderate solvent dependence; a slower reaction was observed in THF[31] (entry 15) relative to ether (entry 16). Conjugate addition of Li[PhCuI] to **1** in ether (entry 18) provided 80% de of **16***S* while the TMSI promoted reaction of Li[PhCuI] in THF (entry 17) provided 92% de of **16***R*.

Koga's glutamic acid derived auxiliary (**4**)[18] was compared to the 2-oxazolidinones under the same reaction conditions. Due to the presence of a large trityl group, the Li[RCuI]/TMSI system provided high stereoselectivities comparable to those of the phenylglycine-derived auxiliary (**1**). The TMSCl promoted conjugate addition of the Gilman reagent, Li[Bu_2Cu]LiI, to substrate **4** gave on the other hand a lower stereoselectivity (entry 39). A noteworthy improvement of the yield was obtained (63%) once the solvent was changed from THF to ether (entry 38), but the stereoselectivity was very low. A significant improvement of both yield and stereoselectivity was obtained using the less reactive Li[Ph_2CuI]LiI reagent in the presence of TMSCl (entry 40). Thus, the Li[RCuI]/TMSI combination is far more efficient to the imides than the TMSCl promoted additions of Gilman reagents. The presence of TMSI also facilitated the conjugate addition of the *tert*-butyl group using Li[*t*-BuCuI] in THF (entries 30, 37). The copper-promoted conjugate additions of RMgBr give no advantage in the presence of TMSI (entries 34, 35). Additionally, entries 19 and 20 illustrate a lower yield obtained in the presence of TMSI, which suggests that the Grignard reagents are incompatible with TMSI.



Scheme 3. Proposed influence of the lithium ion in ether vs THF.

Conjugate additions of various copper reagents to the *N*-heptenoyl-derived auxilaries are collected in Table 2. The efficiency of the auxiliaries follows essentially the same order as the *N*-crotonyl-derived auxilaries previously discussed. Although the MeCu/LiI and PhCu/LiI reagents are less reactive than BuCu/LiI, the Li[MeCuI]/TMSI combination underwent a smooth conjugate addition at −78 °C to imides **5**–**8**. Similarly, the Li[PhCuI]/TMSI system gave high yields to the same imides. In sharp contrast, organocopper combinations such as $LiMe_2Cu$/TMSCl (entry 47) or Li[MeCuI]/BF_3 (entry 49) proved to be completely insufficient in conjugate additions to imides **7** and **8**.

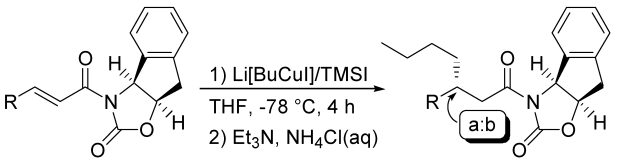
The conjugate additions to the various *N*-cinnamoyl-derived auxiliaries are collected in Table 3. As the *N*-cinnamoyl derivative is slightly less reactive than the *N*-crotonyl and the *N*-heptenoyl analog, a complete consumption of the starting material was achieved by employing two equiv. of the Li[RCuI]/TMSI reagent. Very efficient conjugate additions of MeCu at −78 °C to cinnamates **9**–**12** were obtained employing 2 equiv. of the Li[MeCuI]/TMSI combination. The Li[Me_2Cu]/TMSCl mixture with **11**, in ether or THF, gave a very low yield of product (entries 57, 58). Conducting the conjugate addition of Li[BuCuI] in THF using TMSOTf[7d] (entry 61) instead of TMSI (entry 60), provided a slightly reduced de of product **28***S*.

As a final point, due to the ability for the free rotation of the phenyl group in the phenylglycine-derived auxiliary, we also paid attention to the corresponding indanol auxiliary (Scheme 4).[32] Although the indanol auxiliaries are more rigid and might be expected to give higher stereoselectivities in the conjugate addition of Li[BuCuI]/TMSI, our results show that the indanol auxiliary did not give any advantage over the phenylglycine-derived auxiliary.

3. Conclusions

In this paper we show that the Li[RCuI]/TMSI system is a very efficient reagent in asymmetric conjugate additions to chiral imides. The Li[RCuI] reagent is a versatile reaction system that provides a more economical use of the 'R' group compared with the Gilman type reagents. The presence of TMSI during the conjugate additions of Li[RCuI] in THF gave diastereomeric ratios that were inverted in relationship to conjugate additions conducted with copper-promoted Grignard reagents,[9] copper-promoted zirconium reagents[10] or monosilylcopper reagents Li[$PhMe_2SiCuI$].[11,33] Similarly, Li[RCuI]/TMSI provided an excess of the opposite diastereomer compared to the TMSCl-promoted addition of Li[R_2Cu]LiI. The differentiation between the two possible *Si*- and *Re*-diastereofacial π-faces is likely caused by a chelating counter cation effect, which allows the substrate to react in a different favored conformation. The TMSI-promoted additions of monoorganocuprate reagents seem to undergo an initial copper π-complex formation followed by an alkyl/aryl transfer via the more stable non-chelated *anti-s-cis* conformation.[9f] We have also demonstrated the importance of using the DMS-purified CuI complex, (CuI·0.75DMS), in order to obtain high yields as well as high stereoselectivities in the conjugate addition of Li[RCuI]/TMSI.

Our results also show that the TMSI system is crucial for the asymmetric conjugate addition of the copper reagent, but only in THF or in the presence of 12-crown-4. The reaction is proposed not to involve any halosilane in the critical steps in the conjugate addition conducted in ether. Although the mechanistic details of the organocopper reactions are very elusive, a qualitative pattern using the Li[RCuI] is emerging. Further synthetic developments will be reported in due course.



Scheme 4. 1,4-Additions using the indanol auxiliary.

4. Experimental

4.1. General

All organocopper reactions were conducted under inert atmosphere and in septum capped oven-dried glassware. All new compounds were fully characterized using ^{1}H and ^{13}C NMR, IR and HRMS. Chemical yields are based on purified material (>98% by ^{1}H NMR spectroscopy). ^{1}H (500 MHz) and ^{13}C (125 MHz, standard: $^{13}CDCl_3$, δ=77.23 ppm) NMR spectra were recorded on a Varian 500-MHz instrument using TMS as internal standard (δ=0 ppm). Coupling patterns are abbreviated as s, singlet; d, doublet; t, triplet; q, quartet; se, sextet; qu, quintet; m, multiplet; *J*, coupling. Proton assignments were obtained from COSY and DEPT spectra. Mass spectra were recorded using a VG-ZAB or a VG 7070 instrument. IR spectra were recorded on a Perkin–Elmer 1600 FT-IR instrument. Optical rotations were measured using a Rudolf Autopol III Polarimeter. Elemental analysis was performed by Numega in San Diego. Flash chromatography was conducted using silica gel (Whatman, 60 Å, 230–400 mesh).

4.2. Chemicals

The CuI·0.75DMS complex was prepared from commercially available CuI and DMS according to the procedure described by House.[12] Ether and tetrahydrofuran (THF) were distilled from sodium–benzophenone ketyl and collected when the indicator became deep blue. Triethylamine (Et_3N) was distilled from CaH_2 under argon. BuLi (2.5 or 1.6 M in hexanes), *t*-BuLi (1.7 M in pentane), PhLi (1.8 M cyclohexane/ether) and MeLi (1.4 M in Et_2O) were purchased from Aldrich. Iodotrimetylsilane (TMSI) stabilized with copper chips was purchased from Aldrich and stored septum capped in freezer.

4.3. Preparation of imides 1–14 utilizing BuLi/THF/RCOCl[34]

Typically, butyllithium (1.6 M in hexane, 1.92 mL, 3.08 mmol) was added to a solution of the amide (2.80 mmol) in THF (10 mL) at −78 °C under argon. The resulting mixture was stirred for 45 min and a solution of the corresponding acyl chloride (3.36 mmol, 1.2 equiv.) in THF (5 mL) was added at −78 °C. The reaction mixture was stirred for an additional 30 min and then warmed to ambient temperature. Saturated aqueous ammonium chloride (1 mL) was added to the mixture and then diluted with water (30 mL). After extraction with ether (3×30 mL), the combined organics were dried over $MgSO_4$, filtered and evaporated. The crude product was subsequently purified using chromatography on a silica gel column.

4.4. Typical procedure for TMSI promoted conjugate additions. Preparation of compounds 15–30. Determination of absolute stereochemistry

Appropriate organolithium reagent (1.4–2.0 mmol, 1.25 equiv.) was slowly added to rapidly stirred slurry of CuI·0.75DMS (1.3 equiv.) at −78 °C in THF (10 mL). The resulting dark brown slurry was stirred 20 min at −78 °C, and TMSI (1.25 equiv.) was added drop wise via a gas-tight micro syringe. After 5 min, the appropriate substrate (1 equiv.) dissolved in THF (7–10 mL) was added via the reaction flask wall at −78 °C using a gas-tight syringe. The reaction mixture was stirred for 4 h at −78 °C and dry triethylamine (0.75 mL) was added.[35] After stirring an additional hour at −78 °C, a saturated solution of NH_4Cl/NH_3 (pH ~10) was added (5 mL). After increasing the temperature to +20 °C and removal of septum, the resulting mixture was stirred until a homogenous deep blue solution was obtained. The mixture was then poured out in mixture of ether (25 mL) and water (25 mL) and transferred to a separation funnel. The aqueous phase was extracted with ether (3×25 mL) and the combined organic layers dried over $MgSO_4$. After removal of the solvent, the crude material was dried and the diastereomeric ratio was analyzed using ^{1}H NMR spectroscopy. After purification of the crude product using flash-chromatography (silica gel), the chiral auxilary was disconnected using either KOH in MeOH[18] (pyrrolidinone derivatives) or $LiBH_4$ in ether[19] (oxazolidinone derivatives) to give optically active β-substitued carboxylic acids or corresponding alcohols.

4.5. Conjugate addition of Li[BuCuI] to a homogenous $MgBr_2$–imide complex

$MgBr_2{\cdot}OEt_2$ (0.493 mmol) was added under argon to a stirred solution of imide **1** (0.493 mmol) in anhydrous THF (7 mL) at +20 °C. After 5 min, the homogenous $MgBr_2$-imide complex was added via syringe under argon to Li[BuCuI] at −78 °C, prepared from BuLi (2.5 equiv., 1.23 mmol) and CuI·0.75DMS (1.23 mmol) in anhydrous THF (10 mL). The reaction mixture was next stirred under argon for 4 h at −78 °C. Subsequently, the copper reagent was quenched with a saturated solution of NH_4Cl/NH_3 (pH ~10, 5 mL). After increasing the temperature to +20 °C, the resulting mixture was stirred until a homogenous deep blue solution was obtained. The solution was then poured out in mixture of ether (25 mL) and water (25 mL). The aqueous phase was extracted with ether (3×25 mL) and the combined organic layers dried over $MgSO_4$. After removal of the solvent, the crude material was dried and the diasteromeric ratio was analyzed using ^{1}H NMR spectroscopy (94%). Purification using flash chromatography provided 110 mg (77%) of imide **15** in 94% de (**15***R*).

4.5.1. *N*-(2′*E*-Butenoyl)-4*R*-phenyl-1,3-oxazolidin-2-one (1).[9a] Flash chromatography (30% Et_2O in hexanes; R_f 0.40) yielded 76% (438 mg) of **1** as a white solid; mp 76–78 °C; $[\alpha]_D^{20}$ −110.8° (*c* 0.85, $CHCl_3$) {lit.[9a] mp 77–79 °C; $[\alpha]_D^{22}$ +111.8° for the *S*-enantiomer, (*c* 1.08 $CHCl_3$)}; ^{1}H NMR δ 7.40 (m, Ar–*H*, 2H), 7.34–7.29 (m, Ar–*H*, 3H), 7.28 (dq, COC*H*=CH, 'partly hidden,' *J*=15.3, 1.6 Hz, 1H), 7.09 (dq, COCH=C*H*, *J*=15.3, 7.0 Hz, 1H), 5.48 (dd, NC*H*, *J*=8.7, 3.9 Hz, 1H), 4.69 (dd, OCH_2, *J*=8.8, 8.8 Hz, 1H), 4.27 (dd, OCH_2, *J*=8.9, 3.9 Hz, 1H), 1.93 (dd, CH_3CH=CH, *J*=7.0, 1.7 Hz, 1H); ^{13}C NMR δ 176.5, 164.8, 147.5, 139.4, 129.4, 128.9, 126.2, 122.0, 70.1, 57.9, 18.6; FTIR (film, cm^{-1}) 1780, 1686, 1637; HRMS (EI) calcd for $[C_{13}H_{13}NO_3]$ 231.0895, found 231.0900.

4.5.2. *N*-(2′*E*-Butanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (2).[9e] Flash chromatography (30% Et_2O in pentane, R_f 0.50) yielded 70% (600 mg) of **2** as a clear oil; $[\alpha]_D^{20}$ +93.1°

(c 1.45, $CHCl_3$); ^{1}H NMR δ 7.28 (dt, COC*H*=CH, J=15.3, 1.5 Hz, 1H), 7.15 (dt, COCH=C*H*, J=15.3, 7.0 Hz, 1H), 4.53 (dd, NC*H*, J=7.4, 1.5 Hz, 1H), 4.28 (dd, OCH_2, J=9.2, 1.4 Hz, 1H), 4.24 (dd, OCH_2, J=9.2, 7.6 Hz, 1H), 1.96 (dd, CH_3CH, J=7.0, 1.5 Hz, 3H), 0.94 (s, t-Bu, 9H); ^{13}C NMR δ 165.5, 154.9, 147.0, 122.2, 65.4, 61.0, 36.1, 26.8, 18.7; FTIR (film, cm^{-1}) 1778, 1700, 1634; HRMS (EI) calcd for $[C_{11}H_{18}NO_3]^+$ 212.1287 (MH^+), found 212.1282.

4.5.3. *N*-(2′*E*-Butenoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (3).[34] Flash chromatography (50% Et_2O in pentane; R_f 0.50) yielded 91% (880 mg) of **3** as a white solid, mp 83.3–83.9 °C; $[\alpha]_D^{20}$ +70.1° (c 0.85, $CHCl_3$) {lit.[34] mp 85.0–86.0 °C; $[\alpha]_D$ +77.9°, (c 2.00, $CHCl_3$)}; ^{1}H NMR δ 7.36–7.31 (m, Ar–*H*, 2H), 7.30–7.17 (m, Ar–*H* and olefinic, 5H), 4.73 (m, NC*H*, 1H), 4.21 (dd, CH_2O, J=9.0, 7.7 Hz, 1H), 4.18 (dd, CH_2O, J=9.0, 2.9 Hz, 1H), 3.33 (dd, CH_2Ph, J=13.4, 3.2 Hz, 1H), 2.80 (dd, CH_2Ph, J=13.4, 9.5 Hz, 1H), 1.98 (d, CH_3CH, J=5.6 Hz, 3H); ^{13}C NMR δ 165.2, 153.7, 147.2, 135.6, 129.7, 129.2, 127.5, 122.1, 66.3, 55.5, 38.1, 18.8; FTIR (KBr, cm^{-1}) 1778, 1690, 1636; HRMS (EI) calcd for $[C_{14}H_{15}NO_3]$ 245.1052, found 245.1054.

4.5.4. *N*-(2′*E*-Butenoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (4).[18,36] Flash chromatography (40% EtOAc in hexane; R_f 0.4) yielded 82% of **4** as a colorless solid, mp 115–116 °C; $[\alpha]_D^{20}$ −85.1° (c 1.20, $CHCl_3$) {lit.[18,36] mp 116–117 °C; $[\alpha]_D^{20}$ −86.2° ($CHCl_3$)}; ^{1}H NMR δ 7.31–7.26 (m, Ar–*H*, 6H), 7.22 (dq, C*H*–CO, J=15.2, 1.7 Hz, 1H), 7.22–7.17 (m, Ar–*H*, 6H), 7.17–7.12 (m, Ar–*H*, 3H), 7.02 (dq, C*H*–CH_3, J=15.2, 6.8 Hz, 1H), 4.46 (m, N–C*H*, 1H), 3.50 (dd, CH_2O, J=9.8, 4.0 Hz, 1H), 3.07 (dd, CH_2O, J=9.8, 2.8 Hz, 1H), 2.89 (ddd, α-CH_2, J=17.8, 10.0, 10.3 Hz, 1H), 2.42 (ddd, α-CH_2, J=17.8, 9.9, 1.7 Hz, 1H), 2.06–1.97 (m, CH_2CH_2, 2H), 1.90 (dd, CH_3, J=7.0, 1.7 Hz, 3H); ^{13}C NMR δ 176.6, 165.8, 145.6, 143.7, 128.6, 127.9, 127.1, 124.1, 87.0, 64.2, 56.8, 33.4, 21.2, 18.5; FTIR (KBr, cm^{-1}) 1732, 1678, 1634; HRMS (DCI/NH_3) calcd for $[C_{28}H_{28}NO_3]^+$ 426.2069 (MH^+), found 426.2074.

4.5.5. *N*-(2′*E*-Heptenoyl)-4*R*-phenyl-1,3-oxazolidin-2-one (5). Flash chromatography (20% EtOAc in petroleum ether; R_f 0.50) yielded 72% (525 mg) of **5** as a white solid; mp 71–73 °C; $[\alpha]_D^{20}$ −118.7° (c 1.63, $CHCl_3$); ^{1}H NMR δ 7.40–7.35 (m, Ar–*H*, 2H), 7.34–7.29 (m, Ar–*H*, 3H), 7.25 (dt, COC*H*=CH, J=15.3, 1.5 Hz, 1H), 7.09 (dt, COCH=C*H*, J=15.3, 7.0 Hz, 1H), 5.48 (dd, NC*H*, J=8.8, 3.9 Hz, 1H), 4.69 (dd, OCH_2, J=8.8, 8.8 Hz, 1H), 4.27 (dd, OCH_2, J=8.8, 3.9 Hz, 1H), 2.26 (m, CH_2CH=CH, 2H), 1.44 (qu, CH_2, J=7.2 Hz, 2H), 1.34 (se, CH_2CH$_3$, J=7.2 Hz, 2H), 0.9 (t, CH_3, J=7.2 Hz, 3H); ^{13}C NMR δ 165.0, 154.0, 152.6, 139.4, 129.4, 128.9, 126.2, 120.4, 70.1, 57.9, 32.5, 30.3, 22.4, 13.9; FTIR (film, cm^{-1}) 1780, 1686, 1636; HRMS (EI) calcd for $[C_{16}H_{19}NO_3]$ 273.1365, found 273.1357. Anal. calcd for $C_{16}H_{19}NO_3$: C, 70.31; H, 7.01; N, 5.12. Found: C, 70.46; H, 6.84; N, 4.91.

4.5.6. *N*-(2′*E*-Heptanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (6). Flash chromatography (50% Et_2O in pentane, R_f 0.50) yielded 88% (395 mg) of **6** as a clear syrup; $[\alpha]_D^{20}$ +76.7° (c 1.0, $CHCl_3$); ^{1}H NMR δ 7.26 (dt, C*H*=CHCH$_2$, J=15.4, 1.5 Hz, 1H), 7.14 (dt, CH=C*H*CH$_2$, J=15.4, 7.0 Hz, 1H), 4.51 (dd, NC*H*, J=7.6, 1.8 Hz, 1H), 4.29 (dd, OCH_2, J=9.2, 1.8 Hz, 1H), 4.24 (dd, OCH_2, J=9.2, 7.6 Hz, 1H), 2.28 (m, CH=CHCH_2, 2H), 1.48 (qu, CH_2, 2H), 1.36 (se, CH_2CH$_3$, J=7.6 Hz, 2H), 0.94 (s, t-Bu, 9H), 0.92 (t, CH_3CH$_2$, J=7.2 Hz, 3H); ^{13}C NMR δ 165.7, 154.9, 152.0, 120.6, 65.4, 61.0, 36.1, 32.6, 30.4, 25.8, 22.5, 14.0; FTIR (film, cm^{-1}) 1778, 1688, 1634; HRMS (EI) calcd for $[C_{14}H_{23}NO_3]$ 253.1678, found 253.1679.

4.5.7. *N*-(2′*E*-Heptenoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (7). Flash chromatography (30% Et_2O in pentane; R_f 0.35) yielded 70% (817 mg) of **7** as a white solid; mp 58–60 °C; $[\alpha]_D^{20}$ +90.38° (c 1.31, $CHCl_3$); ^{1}H NMR δ 7.36–7.31 (m, Ar–*H* and olefinic, 2H), 7.29–7.17 (m, Ar–*H* and olefinic, 5H), 4.73 (m, N–C*H*, 1H), 4.21 (dd, CH_2O, J=9.0, 8.1 Hz, 1H), 4.16 (dd, CH_2O, J=9.0, 3.1 Hz, 1H), 3.34 (dd, CH_2Ph, J=13.4, 3.3 Hz, 1H), 2.86 (dd, CH_2Ph, J=13.4, 9.5 Hz, 1H), 2.31 (dt, CH_2–CH=CH, J=7.0, 6.5 Hz, 2H), 1.50 (m, CH_2CH$_2$, 2H), 1.38 (m, CH_2CH$_3$, 2H), 0.92 (t, CH_3CH$_2$, J=7.5 Hz, 3H); ^{13}C NMR δ 165.4, 153.7, 152.2, 135.6, 129.7, 129.2, 127.5, 120.6, 66.3, 55.6, 38.2, 32.6, 30.4, 22.5, 14.0; FTIR (KBr, cm^{-1}) 1778, 1678, 1631; HRMS (EI) calcd for $[C_{17}H_{21}NO_3]$ 287.1521, found 287.1528. Anal. calcd for $C_{17}H_{21}NO_3$: C, 71.06; H, 7.37; N, 4.87. Found: C, 71.40; H, 7.26; N, 4.53.

4.5.8. *N*-(2′*E*-Heptenoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (8).[18] Flash chromatography (30% Et_2O in pentane; R_f 0.4) yielded 72% (0.94 g) of **8** as a light yellow oil; $[\alpha]_D^{20}$ −66.2° (c 1.13, $CHCl_3$) {lit.[18] $[\alpha]_D^{20}$ −64.5° ($CHCl_3$)}; ^{1}H NMR δ 7.38–7.34 (m, Ar–*H*, 6H), 7.33 (dt, C*H*–CO, J=15.4, 1.4 Hz, 1H), 7.27–7.22 (m, Ar–*H*, 6H), 7.21–7.16 (m, Ar–*H*, 3H), 7.10 (dt, CH_2C*H*=CHCO, J=15.4, 7.0 Hz, 1H), 4.51 (m, N–C*H*, 1H), 3.56 (dd, CH_2O, J=9.8, 4.0 Hz, 1H), 3.14 (dd, CH_2O, J=9.8, 2.7 Hz, 1H), 2.94 (ddd, α-CH_2, J=17.8, 10.0, 10.0 Hz, 1H), 2.46 (ddd, α-CH_2, J=17.8, 9.9, 2.0 Hz, 1H), 2.29 (dq, CH_2CH=CH, J=7.0, 1.3 Hz, 2H), 2.07–1.96 (m, CH_2-ring, 1H), 1.96–1.89 (m, CH_2-ring, 1H), 1.53–1.44 (m, CH_2-chain, 2H), 1.43–1.33 (m, CH_2-chain, 2H), 0.92 (t, CH_3CH$_2$, J=7.3 Hz, 3H); ^{13}C NMR δ 176.4, 166.2, 150.9, 143.7, 128.8, 127.1, 127.3, 122.7, 87.2, 64.4, 57.0, 33.6, 32.6, 30.6, 22.5, 21.3, 14.1; FTIR (neat, cm^{-1}) 1733, 1675, 1634; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{31}H_{33}NO_3Na]^+$ 490.2358, found 490.2379.

4.5.9. *N*-(3′-Phenyl-2′*E*-propenoyl-)-4*R*-phenyl-1,3-oxazolidin-2-one (9).[9a] Flash chromatography (15% EtOAc in petroleum ether; R_f 0.40) yielded 88% (642 mg) of **9** as a white solid. Recrystallization (EtOAc/Hexanes) afforded **9** as white crystals; mp 169–170 °C; $[\alpha]_D^{20}$ −3.9° (c 0.85, $CHCl_3$) {lit.[9a] mp 169–171 °C; $[\alpha]_D^{22}$ +3.4° for the *S*-enantiomer, (c 0.74, $CHCl_3$)}; ^{1}H NMR δ 7.93 (d, PhC*H*, J=15.5 Hz, 1H), 7.78 (d, PhCHC*H*, J=15.5 Hz, 1H), 7.61–7.57 (m, Ar–*H*, 2H), 7.42–7.37 (2m, Ar–*H*, 5H), 7.37–7.32 (2m, Ar–*H*, 3H), 5.56 (dd, NC*H*, J=8.7, 3.8 Hz, 1H), 4.74 (dd, OCH_2, J=8.7, 8.7 Hz, 1H), 4.32 (dd, OCH_2, J=8.7, 3.8 Hz, 1H); ^{13}C NMR δ 165.0, 154.0, 146.9, 139.2, 134.7, 130.9, 129.4, 129.1, 128.9, 128.9, 126.2, 117.1, 70.2, 58.1; FTIR (film, cm^{-1}) 1778, 1684, 1622; HRMS (EI) calcd for $[C_{18}H_{15}NO_3]$ 293.1052, found 293.1042.

4.5.10. *N*-(3′-Phenyl-2′*E*-Propanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (10).[37] Flash chromatography (50% Et_2O in pentane; R_f 0.50) yielded 85% (437 mg) of **10** as a clear syrup; $[\alpha]_D^{20}$ +115.5° (*c* 1.50, CH_2Cl_2), {lit.[37] mp 99–100 °C; $[\alpha]_D^{25}$ +115.4, (*c* 0.5, CH_2Cl_2)}; ^{1}H NMR δ 7.95 (d, olefinic, *J*=15.6 Hz, 1H), 7.85 (d, olefinic, *J*=15.6 Hz, 1H), 7.62 (m, Ar–*H*, 2H), 7.39 (m, Ar–*H*, 3H), 4.59 (dd, NC*H*, *J*=7.4, 1.9 Hz, 1H), 4.33 (dd, OCH_2, *J*=9.2, 1.8 Hz, 1H), 4.28 (dd, OCH_2, *J*=9.2, 7.4 Hz, 1H), 0.98 (s, *t*-Bu, 9H); ^{13}C NMR δ 165.8, 155.0, 146.6, 134.9, 130.8, 129.1, 128.8, 117.4, 65.5, 61.2, 36.2, 25.9; FTIR (film, cm^{-1}) 1776, 1683, 1624; HRMS (EI) calcd for $C_{16}H_{19}NO_3$ 273.1365, found 273.1374. Anal. calcd for $C_{16}H_{19}NO_3$: C, 70.31; H, 7.01; N, 5.12. Found: C, 70.60; H, 7.35; N, 4.90.

4.5.11. *N*-(3′-Phenyl-2′*E*-propenoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (11).[38] Flash chromatography (40% Et_2O in pentane; R_f 0.30) yielded 88% (1.22 g) of **11** as a white solid, mp 122–124 °C; $[\alpha]_D^{20}$ +44.6° (*c* 1.0, $CHCl_3$) {lit.[38] mp 121 °C; $[\alpha]_D^{20}$ +45.6 (*c* 1.1 $CHCl_3$)}; ^{1}H NMR δ 7.92 (2d, olefinic, *J*=15.0 Hz, 2H), 7.64 (m, Ar–*H*, 2H), 7.41 (m, Ar–*H*, 3H), 7.34 (t, Ar–*H*, *J*=7.2 Hz, 2H), 7.29 (d, Ar–*H*, *J*=7.2 Hz, 1H), 7.25 (m, Ar–*H*, 2H), 4.81 (m, NC*H*, 1H), 4.26 (dd, CH_2O, *J*=7.2, 7.2 Hz, 1H), 4.21 (dd, CH_2O, *J*=7.2, 2.1 Hz, 1H), 3.38 (dd, CH_2Ph, *J*=12.4, 2.9 Hz, 1H), 2.86 (dd, CH_2Ph, *J*=12.4, 8.3 Hz, 1H); ^{13}C NMR δ 165.4, 153.7, 146.6, 135.6, 134.8, 130.9, 129.7, 129.2, 129.1, 128.9, 127.5, 117.2, 66.4, 55.6, 38.1; FTIR (film, cm^{-1}) 1777, 1678, 1621; HRMS (EI) calcd for [$C_{19}H_{17}NO_3$] 307.1208, found 307.1201.

4.5.12. *N*-(3′-Phenyl-2′*E*-propenoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (12).[18] Flash chromatography (30% Et_2O in pentane; R_f 0.26) yielded 96% of **12** as a colorless oil that solidified upon standing, mp 81–83 °C; $[\alpha]_D^{20}$ −2.3° (*c* 1.3, $CHCl_3$) {lit.[18] oil; $[\alpha]_D$ −1.6° (*c* 9.86 $CHCl_3$)}; ^{1}H NMR δ 7.92 (d, PhC*H*–, *J*=15.8 Hz, 1H), 7.71 (d, PhCH=C*H*, *J*=15.8 Hz, 1H), 7.58–7.54 (m, Ar–*H*, 2H), 7.35–7.26 (m, Ar–*H*, 9H), 7.22–7.10 (m, Ar–*H*, 9H), 4.53 (m, N–C*H*, 1H), 3.55 (dd, CH_2O, *J*=9.8, 3.9 Hz, 1H), 3.13 (dd, CH_2O, *J*=9.8, 2.7 Hz, 1H), 2.94 (ddd, α-CH_2, *J*=17.8, 10.6, 10.0 Hz, 1H), 2.47 (ddd, α-CH_2, *J*=17.8, 9.9, 2.0 Hz, 1H), 2.05 (m, CH_2CH_2, 1H), 1.95 (m, CH_2CH_2, 1H); ^{13}C NMR δ 176.5, 165.9, 145.4, 143.7, 135.2, 130.3, 128.8, 128.6, 128.5, 127.9, 127.1, 119.5, 87.3, 64.4, 57.1, 33.6, 21.3; FTIR (KBr, cm^{-1}) 1730, 1670, 1617; HRMS (FAB DCM/NBA/NaCl) calcd for [$C_{33}H_{29}NO_3Na$]$^+$ 510.2045, found 510.2033.

4.5.13. *N*-(2′*E*-Butenoyl)-(4*S*,5*R*)-indano[1,2-*d*]oxazolidin-2-one (13).[32] Flash chromatography (50% ether in pentane, R_f 0.50 on silica gel) yielded 94% of **13** as a clear solid; mp 116–117 °C. ^{1}H NMR δ 7.67 (d, Ar–*H*, *J*=7.6 Hz, 1H), 7.34 (dd, Ar–*H*, *J*=7.6 Hz, 1H), 7.30–7.20 (m, olefinic and Ar–*H*, 4H), 5.98 (d, NC*H*, *J*=6.8 Hz, 1H), 5.29 (m, OC*H*, 1H), 3.39 (m, ArCH_2, 2H), 1.97 (d, CH_3, *J*=4.7 Hz, 3H); ^{13}C NMR δ 166.0, 153.7, 147.6, 140.1, 139.9, 130.5, 128.8, 128.1, 125.8, 122.5, 78.7, 63.9, 38.7, 19.2; FTIR (CH_2Cl_2, cm^{-1}) 1774.2, 1682.7, 1636.4; HRMS (EI) calc for [$C_{14}H_{13}NO_3$] 243.0895, found 243.0896.

4.5.14. *N*-(3′-Phenyl-2′*E*-propenoyl)-(4*S*,5*R*)-indano[1,2-*d*]-oxazolidin-2-one (14).[37] Flash chromatography (50% ether in pentane, R_f 0.50 on silica gel) yielded 51% of **14** as a clear solid; mp 195–196 °C; $[\alpha]_D^{20}$ +292° (*c* 0.65, CH_2Cl_2) {lit.[37] mp 185–188 °C; $[\alpha]_D^{25}$ −280° for the 4*R*,5*S* isomer (*c* 1.0 CH_2Cl_2)}; ^{1}H NMR δ 7.95 (d, olefinic, *J*=15.7 Hz, 1H), 7.92 (d, olefinic, *J*=15.7 Hz, 1H), 7.73 (d, Ar–*H*, *J*=7.7 Hz, 1H), 7.64–7.61 (m, Ar–*H*, 2H), 7.41–7.27 (m, Ar–*H*, 6H), 6.07 (d, NC*H*, *J*=6.9 Hz, 1H), 5.35–5.31 (m, OC*H*, 1H), 3.42 (m, CH_2, 2H); ^{13}C NMR δ 165.6, 153.1, 146.5, 139.5, 139.2, 134.6, 130.7, 129.9, 128.9, 128.7, 128.2, 127.5, 125.2, 117.0, 78.1, 63.4, 38.0; FTIR (film, cm^{-1}) 1774, 1675, 1621; MS: m/z=328 (M+Na^+, 100%).

4.5.15. *N*-(3′*R*-Methylheptanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (15*R*). Obtained from the reaction using imide **5** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (20% EtOAc in petroleum ether; R_f 0.40) to give 84% (82% de) of **15***R* as a white solid; mp 46–49 °C; ^{1}H NMR δ 7.40–7.35 (m, Ar–*H*, 2H), 7.35–7.32 (m, Ar–*H*, 1H), 7.32–7.28 (m, Ar–*H*, 2H), 5.44 (dd, NC*H*, *J*=8.8, 3.8 Hz, 1H), 4.68 (dd, OCH_2, *J*=8.9, 8.8 Hz, 1H), 4.27 (dd, OCH_2, *J*=8.9, 3.8 Hz, 1H), 2.99 (dd, COCH_2, *J*=16.0, 5.4 Hz, 1H), 2.68 (dd, COCH_2, *J*=16.0, 8.6 Hz, 1H), 1.99 (m, methine, 1H), 1.32–1.13 (m, 3× CH_2, 6H), 0.85 (d, CH_3CH, 'partly hidden,' *J*=6.6 Hz, 3H), 0.84 (t, CH_3CH_2, 'partly hidden,' *J*=6.7 Hz, 3H); ^{13}C NMR δ 172.6, 153.9, 139.5, 129.4, 128.9, 126.2, 70.0, 57.8, 42.8, 36.8, 29.9, 29.3, 23.0, 19.8, 14.2; FTIR (film, cm^{-1}) 1782, 1702; HRMS (EI) calcd for $C_{17}H_{23}NO_3$ 289.1678, found 289.1689.

4.5.16. *N*-(3′*S*-Methylheptanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (15*S*). Obtained from the reaction using imide **1** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.40) to give 83% (96% de) of **15***S* as a white solid; mp 58–60 °C; ^{1}H NMR δ 7.40–7.35 (m, Ar–*H*, 2H), 7.35–7.32 (m, Ar–*H*, 1H), 7.32–7.28 (m, Ar–*H*, 2H), 5.43 (dd, NC*H*, *J*=8.8, 3.8 Hz, 1H), 4.68 (dd, OCH_2, *J*=8.8, 8.8 Hz, 1H), 4.26 (dd, OCH_2, *J*=8.8, 3.8 Hz, 1H), 2.84 (d, COCH_2, *J*=7.0 Hz, 2H), 1.98 (m, methine, 1H), 1.31–1.09 (m, 3× CH_2, 6H), 0.87 (d, CH_3CH, *J*=6.6 Hz, 3H), 0.85 (t, CH_3CH_2, *J*=7.0 Hz, 3H); ^{13}C NMR δ 172.6, 153.9, 139.5, 129.4, 128.9, 126.1, 70.0, 57.8, 42.8, 36.5, 30.0, 29.4, 23.0, 19.9, 14.3; FTIR (film, cm^{-1}) 1782, 1702; HRMS (EI) calcd for [$C_{17}H_{24}NO_3$]$^+$ (MH^+) 290.1756, found 290.1764.

4.5.17. *N*-(3′*R*-Phenylbutanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (16*R*). Obtained from the reaction using imide **1** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.35) to give 83% of **16***R* (92% de) as a white solid; mp 138–142 °C; ^{1}H NMR δ 7.37–7.15 (4m, Ar–*H*, 10H), 5.28 (dd, NC*H*, *J*=8.7, 3.4 Hz, 1H), 4.52 (dd, OCH_2, *J*=8.8, 8.7 Hz, 1H), 4.19 (dd, OCH_2, *J*=8.8, 3.4 Hz, 1H), 3.38 (dd, COCH_2, *J*=16.0, 8.0 Hz, 1H), 3.32 (se, methine, *J*=7.0 Hz, 1H), 3.13 (dd, COCH_2, *J*=16.0, 6.1 Hz, 1H), 1.25 (d, CH_3CH, *J*=6.8 Hz, 3H); ^{13}C NMR δ 171.5, 153.9, 145.8, 139.3, 129.3, 128.8, 128.6, 127.2, 126.5, 126.1, 70.1, 57.7, 43.4, 36.1, 22.4; FTIR (film, cm^{-1}) 1782, 1707; HRMS (EI) calcd for [$C_{19}H_{19}NO_3$] 309.1365, found 309.1358.

4.5.18. *N*-(3′*S*-Phenylbutanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (16*S*). Obtained from the reaction using

cinnamate **9** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.30) to give 80% of **16*S*** (84% de) as a white solid; ^1H NMR δ 7.40–7.15 (m, Ar–*H*, 8H), 7.10–7.04 (m, Ar–*H*, 2H), 5.38 (dd, NC*H*, *J*=8.8, 3.9 Hz, 1H), 4.62 (dd, OCH_2, *J*=8.8, 8.8 Hz, 1H), 4.17 (dd, OCH_2, *J*=8.8, 3.9 Hz, 1H), 3.47 (dd, COCH_2, *J*=15.9, 6.7 Hz, 1H), 3.32 (m, methine, 1H), 3.05 (dd, COCH_2, *J*=15.9, 7.9 Hz, 1H), 1.25 (d, CH_3CH, *J*=7.0 Hz, 3H); ^{13}C NMR δ 171.6, 153.8, 145.7, 139.0, 129.3, 128.6, 128.6, 127.1, 126.5, 125.8, 70.0, 57.7, 43.3, 36.2, 21.9; FTIR (film, cm^{-1}) 1780, 1702. HRMS (EI) calcd for $C_{19}H_{19}NO_3$ 309.1365, found 309.1371.

4.5.19. *N*-(3′*R*-Methylheptanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (17*R*). Obtained from the reaction using imide **2** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (10% Et_2O in pentane; R_f 0.50) to give 80% (86% de) of **17*R*** as a clear oil; ^1H NMR δ 4.45 (dd, NC*H*, *J*=7.6, 1.6 Hz, 1H), 4.27 (dd, OCH_2, *J*=9.3, 1.6 Hz, 1H), 4.24 (dd, OCH_2, *J*=9.3, 7.7 Hz, 1H), 2.87 (dd, COCH_2, *J*=16.4, 7.7 Hz, 1H), 2.81 (dd, COCH_2, *J*=16.4, 5.9 Hz, 1H) 2.04 (m, methine, 1H), 1.43–1.16 (m, 3× CH_2, 6H), 0.98 (d, CH_3CH, *J*=6.7 Hz, 3H), 0.93 (s, *t*-Bu, 9H), 0.89 (t, CH_3CH$_2$, *J*=6.8 Hz, 3H); ^{13}C NMR δ 173.1, 154.9, 65.4, 61.1, 42.7, 36.6, 35.9, 30.0, 29.4, 25.9, 23.0, 20.0, 14.3; FTIR (film, cm^{-1}) 1780, 1703; HRMS (EI) calcd for $[C_{15}H_{28}NO_3]^+$ (MH^+) 270.2069, found 270.2068.

4.5.20. *N*-(3′*S*-Methylheptanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (17*S*). Obtained from the reaction using imide **6** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (10% Et_2O in pentane; R_f 0.50) to give 71% (86% de) of **17*S*** as a clear oil; ^1H NMR δ 4.45 (dd, NC*H*, *J*=7.5, 1.6 Hz, 1H), 4.28 (dd, OCH_2, *J*=9.2, 1.7 Hz, 1H), 4.22 (dd, OCH_2, *J*=9.2, 7.6 Hz, 1H), 3.00 (dd, COCH_2, *J*=16.0, 5.5 Hz, 1H), 2.66 (dd, COCH_2, *J*=16.0, 8.1 Hz, 1H) 2.07 (m, methine, 1H), 1.43–1.19 (m, 3× CH_2, 6H), 0.96 (d, CH_3CH, *J*=6.7 Hz, 3H), 0.94 (s, *t*-Bu, 9H), 0.89 (t, CH_3CH$_2$, *J*=7.1 Hz, 3H); ^{13}C NMR δ 173.1, 154.9, 65.5, 61.1, 42.7, 36.8, 36.0, 30.1, 29.3, 25.9, 23.1, 19.9, 14.3; FTIR (film, cm^{-1}) 1781, 1705; HRMS (EI) calcd for $[C_{15}H_{28}NO_3]^+$ 270.2069, found 270.2064.

4.5.21. *N*-(3′*R*-Phenylbutanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (18*R*). Obtained from the reaction using imide **10** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.40) to give 80% (90% de) of **18*R*** as a white solid; mp 72.6–73.7 °C; ^1H NMR δ 7.30–7.24 (m, Ar–*H*, 4H), 7.20–7.15 (m, Ar–*H*, 1H), 4.37 (dd, NC*H*, *J*=7.6, 1.7 Hz, 1H), 4.23 (dd, OCH_2, *J*=9.3, 1.7 Hz, 1H), 4.18 (dd, OCH_2, *J*=9.3, 7.6 Hz, 1H), 3.53 (dd, COCH_2, *J*=16.1, 7.6 Hz, 1H), 3.40 (se, methine, *J*=7.0 Hz, 1H), 3.10 (dd, COCH_2, *J*=16.1, 7.1 Hz, 1H), 1.33 (d, CH_3CH, *J*=7.1 Hz, 3H), 0.75 (s, *t*-Bu, 9H); ^{13}C NMR δ 172.1, 154.8, 145.9, 128.6, 127.2, 126.5, 65.4, 61.0, 43.1, 36.5, 35.7, 25.6, 22.5; FTIR (film, cm^{-1}) 1779, 1706; HRMS (EI) calcd for $[C_{17}H_{23}NO_3]$ 289.1678, found 289.1689.

4.5.22. *N*-(3′*S*-Phenylbutanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (18*S*). Obtained from the reaction using imide **2** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.45) to give 75% (90% de) of **18*S*** as a white solid; ^1H NMR δ 7.31–7.21 (m, Ar–*H*, 4H), 7.20–7.16 (m, Ar–*H*, 1H), 4.30 (NC*H*, *J*=7.7, 1.0 Hz, 1H), 4.19 (dd, OCH_2, *J*=9.0, 1.3 Hz, 1H), 4.02 (dd, OCH_2, *J*=9.0, 7.8 Hz, 1H), 3.40 (m, methine, 'partly hidden,' 1H), 3.37 (dd, COCH_2, 'partly hidden,' 1H), 3.17 (dd, COCH_2, *J*=15.3, 5.7 Hz, 1H), 1.34 (d, CH_3CH, *J*=6.7 Hz, 3H), 0.88 (s, *t*-Bu, 9H); ^{13}C NMR δ 172.2, 154.9, 145.8, 128.7, 127.3, 126.6, 65.5, 61.2, 43.2, 36.6, 35.9, 25.8, 22.6; FTIR (film, cm^{-1}) 1779, 1704; HRMS (EI) calcd for $C_{17}H_{23}NO_3$ 289.1678, found 289.1673.

4.5.23. *N*-(3′*R*-Methylheptanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (19*R*). Obtained from the reaction using imide **3** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.50) to give 98% (70% de) of **19*R*** as a clear oil; ^1H NMR δ 7.37–7.33 (m, Ar–*H*, 2H), 7.32–7.27 (m, Ar–*H*, 1H), 7.25–7.22 (m, Ar–*H*, 2H), 4.71 (m, NC*H*, 1H), 4.21 (dd, OCH_2, *J*=9.0, 7.0 Hz, 1H), 4.17 (dd, OCH_2, *J*=9.0, 2.5 Hz, 1H), 3.34 (dd, PhCH_2, *J*=12.0, 3.0 Hz, 1H), 2.92 (dd, COCH_2, *J*=15.5, 4.5 Hz, 1H), 2.84 (dd, COCH_2, *J*=15.5, 6.0 Hz, 1H), 2.78 (dd, PhCH_2, *J*=12.0, 9.0 Hz, 1H), 2.10 (m, methine, 1H), 1.46–1.20 (m, 3× CH_2, 6H), 1.02 (d, CH_3CH, *J*=6.0 Hz, 3H), 0.92 (t, CH_3CH$_2$, *J*=6.5 Hz, 3H); ^{13}C NMR δ 173.1, 153.6, 135.6, 129.6, 129.2, 127.5, 66.3, 55.4, 42.7, 38.2, 36.7, 29.9, 29.4, 23.0, 20.00, 14.3; FTIR (film, cm^{-1}) 1780, 1700; HRMS (EI) calcd for $[C_{18}H_{26}NO_3]^+$ (MH^+) 304.1913, found 304.1921.

4.5.24. *N*-(3′*S*-Methylheptanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (19*S*). Obtained from the reaction using imide **7** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.25) to give 86% (65% de) of **19*S*** as slight yellow syrup; ^1H NMR δ 7.35–7.30 (m, Ar–*H*, 2H), 7.29–7.24 (m, Ar–*H*, 1H), 7.21 (m, Ar–*H*, 1H), 4.18 (dd, OCH_2, *J*=9.0, 7.6 Hz, 1H), 4.14 (dd, OCH_2, *J*=9.0, 3.0 Hz, 1H), 3.31 (dd, PhCH_2, *J*=13.4, 3.3 Hz, 1H), 2.98 (dd, COCH_2, *J*=16.1, 5.5 Hz, 1H), 2.74 (dd, PhCH_2, 'partly hidden,' *J*=13.4, 9.6 Hz, 1H), 2.72 (dd, COCH_2, *J*=16.1, 8.3 Hz, 1H), 2.08 (m, methine, 1H), 1.44–1.19 (m, 3× CH$_2$, 6H), 0.98 (d, CH_3CH, *J*=6.6 Hz, 3H), 0.90 (t, CH_3CH2, *J*=6.8 Hz, 3H); ^{13}C NMR δ 173.0, 153.6, 135.6, 129.6, 129.1, 127.5, 66.3, 55.4, 42.7, 38.2, 36.8, 29.8, 29.3, 23.0, 19.9, 14.2; FTIR (film, cm^{-1}) 1780, 1699; HRMS (EI) calcd for $[C_{18}H_{25}NO_3]$ 303.1834, found 303.1832.

4.5.25. *N*-(3′*R*-Phenylbutanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (20*R*). Obtained from the reaction using imide **11** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.40) to give 83% (72% de) of **20*R*** as a white solid; ^1H NMR δ 7.33–7.14 (m, Ar–*H*, 8H), 7.08–7.05 (m, Ar–*H*, 2H), 4.64 (m, NC*H*, 1H), 4.15 (dd, OCH_2, *J*=9.0, 7.9 Hz, 1H), 4.10 (dd, OCH_2, *J*=9.0, 3.0 Hz, 1H), 3.50–3.38 (m, COCH_2 and methine, 2H), 3.11–3.04 (m, COCH_2 and CH_2Ph, 2H), 2.59 (dd, CH_2Ph, *J*=13.6, 9.4 Hz, 1H), 1.35 (t, CH_3CH, *J*=6.8 Hz, 3H); ^{13}C NMR δ 172.2, 153.6, 145.9, 135.4, 129.6, 129.1, 128.7, 127.5, 127.3, 126.6, 66.2, 55.2, 43.4, 37.8, 36.2, 22.2; FTIR (film, cm^{-1}) 1781, 1700; HRMS (EI) calcd for $[C_{20}H_{21}NO_3]$ 323.1521, found 323.1524.

4.5.26. *N*-(3′*S*-Phenylbutanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (20*S*). Obtained from the reaction using crotonate **3** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.40) to give 86% (74% de) of **20***S* as white crystals; mp 113–115 °C; ^{1}H NMR δ 7.35–7.17 (m, Ar–*H*, 10H), 4.55 (m, NC*H*, 1H), 4.10 (dd, OCH_2, *J*=9.0, 2.7 Hz, 1H), 4.05 (dd, OCH_2, *J*=9.0, 7.8 Hz, 1H), 3.42 (m, methine, 'partly hidden,' 1H), 3.37 (m, COCH_2, 'partly hidden,' 1H), 3.25 (dd, CH_2Ph, *J*=13.4, 3.3 Hz, 1H), 3.18 (dd, COCH_2, *J*=15.8, 5.9 Hz, 1H), 2.70 (dd, CH_2Ph, *J*=13.4, 9.8 Hz, 1H), 1.38 (d, CH_3CH, *J*=6.8 Hz, 3H); ^{13}C NMR δ 172.1, 153.6, 145.9, 135.5, 129.6, 129.2, 128.7, 127.5, 127.2, 126.6, 66.3, 55.4, 43.5, 38.1, 36.4, 22.4; FTIR (film, cm^{-1}) 1781, 1704; HRMS (EI) calcd for $C_{20}H_{21}NO_3$ 323.1521, found 323.1532.

4.5.27. *N*-(4′,4′-Dimethyl-3′*S*-methylpentanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (21*S*). Obtained from the reaction using imide **3** and *t*-BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.45) to give 85% (74% de) of **21***S* as a white solid; mp 126–127 °C; ^{1}H NMR δ 7.36–7.31 (m, Ar–*H*, 2H), 7.29–7.26 (m, Ar–*H*, 1H), 7.23–7.20 (m, Ar–*H*, 2H), 4.68 (m, NC*H*, 1H), 4.18 (dd, OCH_2, *J*=9.0, 7.7 Hz, 1H), 4.15 (dd, OCH_2, *J*=9.0, 3.0 Hz, 1H), 3.33 (dd, PhCH_2, *J*=13.4, 3.3 Hz, 1H), 3.02 (dd, COCH_2, *J*=16.2, 3.1 Hz, 1H), 2.78 (dd, COCH_2, *J*=16.2, 10.2 Hz, 1H), 2.76 (m, PhCH_2, 'partly hidden,' 1H), 2.02–1.92 (m, methine, 1H), 0.94 (d, CH_3CH, *J*=6.8 Hz, 3H), 0.91 (s, *t*-Bu, 9H); ^{13}C NMR δ 174.0, 153.6, 135.6, 129.6, 129.2, 127.5, 66.3, 55.6, 39.3, 38.4, 38.3, 33.1, 27.4, 15.3; FTIR (film, cm^{-1}) 1779, 1645; HRMS (EI) calcd for $C_{18}H_{25}NO_3$ 303.1834, found 303.1845. Anal. calcd for $C_{18}H_{25}NO_3$: C, 71.26; H, 8.31; N, 4.62. Found: C, 71.10; H, 8.07; N, 4.23.

4.5.28. *N*-(3′*R*-Methylheptanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (22*R*). Obtained from the reaction using imide **8** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (20% Et_2O in pentane; R_f 0.30) to give 91% (93% de) of **22***R* as a colorless syrup; ^{1}H NMR δ 7.31–7.26 (m, Ar–*H*, 6H), 7.24–7.13 (m, Ar–*H*, 9H), 4.41 (m, N–C*H*, 1H), 3.47 (dd, CH_2O, *J*=9.0, 3.6 Hz, 1H), 3.09 (dd, CH_2O, *J*=9.0, 1.8 Hz, 1H), 2.87 (m, α-CH_2CH$_2$ 'partly hidden,' 1H), 2.83 (dd, CH_2CH, *J*=15.0, 4.5 Hz, 1H), 2.67 (dd, CH_2CH, *J*=15.0, 6.5 Hz, 1H), 2.39 (ddd, α-CH_2CH$_2$, *J*=17.5, 10.0, 1.0 Hz, 1H), 1.99 (m, CH_2CH$_2$-ring, 1H), 1.93 (m, C*H*CH$_2$, 1H), 1.85 (m, CH_2CH$_2$-ring, 1H), 1.35–1.10 (m, 3× CH_2, 6H), 0.84 (d, CH_3–CH, *J*=6.0 Hz, 3H), 0.77 (t, CH_3CH$_2$, *J*=6.0 Hz, 3H); ^{13}C NMR δ 176.4, 173.7, 143.9, 128.8, 128.1, 127.4, 87.2, 64.2, 56.8, 44.4, 37.0, 33.5, 29.52, 29.49, 23.1, 21.5, 20.0, 14.3; FTIR (film, cm^{-1}) 1733, 1690; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{32}H_{37}NO_3Na]^+$ 506.2671, found 506.2660.

4.5.29. *N*-(3′*S*-Methylheptanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (22*S*). Obtained from the reaction of crotonate **4** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (20% Et_2O in pentane; R_f 0.30) to give 95% (88% de) of **22***S* as a colorless syrup; ^{1}H NMR δ 7.27–7.23 (m, Ar–*H*, 6H), 7.19–7.09 (m, Ar–*H*, 9H), 4.37 (m, N–C*H*, 1H), 3.45 (dd, CH_2O, *J*=9.2, 3.4 Hz, 1H), 3.04 (dd, CH_2O, *J*=9.2, 1.9 Hz, 1H), 2.85 (dd, CH_2CH, *J*=16.5, 4.8 Hz, 1H), 2.81 (m, α-CH_2CH$_2$ 'partly hidden,' 1H), 2.60 (dd, CH_2CH, *J*=16.5, 7.4 Hz, 1H), 2.35 (ddd, α-CH_2CH$_2$, *J*=17.5, 9.8, 1.6 Hz, 1H), 1.97 (m, CH_2CH$_2$-ring, 1H), 1.89 (m, C*H*CH$_2$, 1H), 1.81 (m, CH_2CH$_2$-ring, 1H), 1.28–1.06 (m, 3× CH_2, 6H), 0.84 (d, CH_3–CH, *J*=5.8 Hz, 3H), 0.77 (t, CH_3CH$_2$, *J*=5.8 Hz, 3H); ^{13}C NMR δ 176.4, 173.7, 143.9, 128.8, 128.1, 127.3, 87.2, 64.2, 56.9, 44.4, 36.9, 33.5, 29.4, 29.4, 23.1, 21.5, 20.2, 14.3; FTIR (film, cm^{-1}) 1733, 1690; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{32}H_{37}NO_3Na]^+$ 506.2671, found 506.2694.

4.5.30. *N*-(3′*R*-Phenylbutanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (23*R*). Obtained from the reaction using crotonate **4** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane, R_f 0.25) in 94% (80% de). Partly separation of the diastereomers yielded 90% of **23***R* (93% de) as a white solid; ^{1}H NMR δ 7.30–7.07 (3m, Ar–*H*, 20H), 4.29 (m, N–C*H*, 1H), 3.46 (dd, CH_2O, *J*=9.7, 3.2 Hz, 1H), 3.34 (dd, CH_2CH *J*=16.1, 6.5 Hz, 1H), 3.25 (qdd, Ph–C*H*, *J*=6.5 Hz, 1H), 3.06 (dd, CH_2O, *J*=9.7, 2.4 Hz, 1H), 3.00 (dd, CH_2CH *J*=16.1, 6.5 Hz, 1H), 2.82 (ddd, α-CH_2, *J*=18.0, 11.3, 9.2 Hz, 1H), 2.32 (ddd, α-CH_2, *J*=18.0, 9.2, 1.7 Hz, 1H), 1.89, 1.83 (m, CH$_2$CH_2, 1H each), 1.25 (d, CH_3–CH, *J*=6.8 Hz, 3H); ^{13}C NMR δ 176.5, 172.7, 146.5, 143.9, 128.8, 128.6, 128.1, 127.4, 127.3, 126.4, 87.2, 64.2, 56.9, 45.2, 35.9, 33.4, 22.5, 21.4; FTIR (KBr, cm^{-1}) 1732, 1694; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{34}H_{33}NO_3Na]^+$ 526.2358, found 526.2380.

4.5.31. *N*-(3′*S*-Phenylbutanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (23*S*). Obtained from the reaction using cinnamate **12** and MeCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane, R_f 0.20) in 99% (93% de). Partly separation of the diastereomers yielded 94% of **23***S* (98% de) as a white solid; ^{1}H NMR δ 7.27–7.08 (3m, Ar–*H*, 20H), 4.37 (m, N–C*H*, 1H), 3.37 (dd, CH_2O, *J*=9.8, 4.0 Hz, 1H), 3.26 (m, Ph–C*H*, 1H), 3.19 (dd, CH_2CH *J*=16.4, 5.3 Hz, 1H), 3.10 (dd, CH_2CH, *J*=16.4, 8.4 Hz, 1H), 3.06 (dd, CH_2O, *J*=9.8, 2.2 Hz, 1H), 2.81 (ddd, α-CH_2-ring, *J*=16.8, 10.8, 8.4 Hz, 1H), 2.37 (ddd, α-CH_2-ring, *J*=16.8, 8.4, 1.2 Hz, 1H), 1.98, 1.82 (m, CH_2CH$_2$, 1H each), 1.21 (d, CH_3–CH, *J*=6.8 Hz, 3H); ^{13}C NMR δ 176.4, 172.8, 146.6, 143.8, 128.8, 128.7, 127.1, 127.3, 127.2, 126.4, 87.2, 64.0, 56.9, 45.2, 35.8, 33.4, 22.2, 21.5; FTIR (KBr, cm^{-1}) 1735, 1692; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{34}H_{33}NO_3Na]^+$ 526.2358, found 526.2360.

4.5.32. *N*-(4′,4′-Dimethyl-3′*R*-methylpentanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (24*R*). Obtained from the reaction using crotonate **4** and *t*-BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.45) to give 90% (77% de) of **24***R* as a white solid; ^{1}H NMR δ 7.39–7.34 (m, Ar–*H*, 6H), 7.32–7.20 (m, Ar–*H*, 9H), 4.48 (m, N–C*H*, 1H), 3.57 (dd, CH_2O, *J*=9.0, 3.2 Hz, 1H), 3.14 (dd, CH_2O, *J*=9.0, 1.9 Hz, 1H), 3.10 (dd, CH_2CH, *J*=16.1, 2.5 Hz, 1H), 2.95 (ddd, α-CH_2CH$_2$, *J*=17.5, 10.4, 10.4 Hz, 1H), 2.67 (dd, CH_2CH, *J*=16.1, 10.0 Hz, 1H), 2.43 (ddd, α-CH_2CH$_2$, *J*=17.5, 9.5, 0.9 Hz, 1H), 2.07 (m, CH_2-ring, 1H), 1.92 (m, CH_2-ring,

1H), 1.88 (m, C*H*CH_2, 'partly hidden,' 1H), 0.90 (s, *t*-Bu, 9H), 0.88 (d, CH_3CH, *J*=6.0 Hz, 3H); ^{13}C NMR δ 176.4, 174.6, 143.9, 128.8, 128.1, 127.4, 87.2, 64.3, 57.0, 40.1, 38.7, 33.6, 33.1, 27.5, 21.5, 15.4; FTIR ($CHCl_3$, cm^{-1}) 1733, 1690.

4.5.33. *N*-(3′*R*-Phenylheptanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (25*R*). Obtained from the reaction using imide **5** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (20% EtOAc in petroleum ether; R_f 0.35) to give 83% (94% de) of **25***R* as a white solid; mp 102–104 °C; ^{1}H NMR δ 7.37–7.29 (m, Ar–*H*, 3H), 7.27–7.21 (m, Ar–*H*, 4H), 7.19–7.14 (m, Ar–*H*, 3H), 5.24 (dd, NC*H*, *J*=8.5, 3.4 Hz, 1H), 4.49 (dd, OCH_2, *J*=8.8, 8.8 Hz, 1H), 4.19 (dd, OCH_2, *J*=8.8, 3.4 Hz, 1H), 3.44 (dd, COCH_2, *J*=17.7, 10.5 Hz, 1H), 3.14 (dd, COCH_2, 'partly hidden,' *J*=17.7, 5.4 Hz, 1H), 3.13 (m, methine, 'partly hidden,' 1H), 1.60 (m, CH_2, 2H), 1.24–1.10 (m, 2×CH_2, 4H), 0.78 (t, CH_3CH$_2$, *J*=7.2 Hz, 3H); ^{13}C NMR δ 171.7, 153.9, 144.4, 139.3, 129.3, 128.8, 128.5, 127.9, 126.5, 126.1, 70.1, 57.8, 42.3, 41.9, 36.4, 29.7, 22.8, 14.1; FTIR (film, cm^{-1}) 1781, 1706; HRMS (EI) calcd for [$C_{22}H_{25}NO_3$] 351.1834, found 351.1821.

4.5.34. *N*-(3′*S*-Phenylheptanoyl)-4*S*-phenyl-1,3-oxazolidin-2-one (25*S*). Obtained from the reaction using imide **9** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (20% EtOAc in petroleum ether; R_f 0.45) to give 96% (83% de) of **25***S* as a white solid; mp 95–98 °C; ^{1}H NMR δ 7.26–7.14 (m, Ar–*H*, 8H), 6.98–6.95 (m, Ar–*H*, 2H), 5.36 (dd, NC*H*, *J*=8.8, 4.2 Hz, 1H), 4.62 (dd, OCH_2, *J*=8.8, 8.8 Hz, 1H), 4.16 (dd, OCH_2, *J*=8.8, 4.2 Hz, 1H), 3.53 (dd, COCH_2, *J*=15.4, 7.3 Hz, 1H), 3.14 (qu, methine, *J*=7.0 Hz, 1H), 3.07 (dd, COCH_2, *J*=15.4, 6.9 Hz, 1H), 1.60 (m, CH_2, 2H), 1.26–1.02 (m, 2×CH_2, 4H), 0.79 (t, CH_3CH$_2$, *J*=7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.9, 153.8, 144.2, 138.9, 129.3, 128.69, 128.57, 127.9, 126.5, 125.7, 70.0, 57.8, 42.12, 42.10, 36.2, 29.8, 22.8, 14.1; FTIR (film, cm^{-1}) 1782, 1702; HRMS (EI) calcd for [$C_{22}H_{25}NO_3$] 351.1834, found 351.1848.

4.5.35. *N*-(3′*R*-Phenylheptanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (26*R*). Obtained from the reaction using imide **10** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.40) to give 83% (82% de) of **26***R* as a white solid; mp 68–71 °C; ^{1}H NMR δ 7.30–7.13 (m, Ar–*H*, 5H), 4.33 (dd, NC*H*, *J*=7.6, 1.7 Hz, 1H), 4.21 (dd, OCH_2, *J*=9.2, 1.7 Hz, 1H), 4.15 (dd, OCH_2, *J*=9.2, 7.6 Hz, 1H), 3.58 (dd, COCH_2, *J*=16.1, 8.8 Hz, 1H), 3.20 (m, methine, 1H), 3.03 (dd, COCH_2, *J*=16.1, 6.1 Hz, 1H), 1.65 (m, CH_2, 2H), 1.35–1.07 (m, 2×CH_2, 4H), 0.83 (t, CH_3CH$_2$, *J*=7.3 Hz, 3H), 0.68 (s, *t*-Bu, 9H); ^{13}C NMR δ 172.3, 154.8, 144.4, 128.5, 128.0, 126.5, 65.3, 61.0, 42.3, 41.7, 36.6, 35.6, 29.8, 25.5, 22.8, 14.1; FTIR (film, cm^{-1}) 1778, 1706; HRMS (EI) calcd for [$C_{20}H_{29}NO_3$] 331.2147, found 331.2155.

4.5.36. *N*-(3′*S*-Phenylheptanoyl)-4*S*-*tert*-butyl-1,3-oxazolidin-2-one (26*S*). Obtained from the reaction using imide **6** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.40) to give 90% (82% de) of **26***S* as a clear syrup; ^{1}H NMR δ 7.29–7.23 (m, Ar–*H*, 2H), 7.23–7.15 (m, Ar–*H*, 3H), 4.23 (dd, NC*H*, *J*=7.7, 1.4 Hz, 1H), 4.15 (dd, OCH_2, *J*=9.2, 1.5 Hz, 1H), 3.93 (dd, OCH_2, *J*=9.2, 7.7 Hz, 1H), 3.41 (dd, COCH_2, *J*=15.5, 8.8 Hz, 1H), 3.21 (m, methine, 1H), 3.15 (dd, COCH_2, *J*=15.5, 5.6 Hz, 1H), 1.73–1.60 (m, CH_2, 2H), 1.34–1.06 (m, 2×CH_2, 4H), 0.85 (s, *t*-Bu, 9H), 0.83 (t, CH_3CH$_2$, *J*=7.3 Hz, 3H); ^{13}C NMR δ 172.3, 154.9, 144.3, 128.5, 128.0, 126.6, 65.4, 61.3, 42.4, 41.9, 36.6, 35.8, 29.7, 25.8, 22.8, 14.1; FTIR (film, cm^{-1}) 1774, 1702; HRMS (EI) calcd for [$C_{20}H_{29}NO_3$] 331.2147, found 331.2150.

4.5.37. *N*-(3′R-Phenylheptanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (27*R*). Obtained from the reaction using cinnamate **11** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexane; R_f 0.40) to give 91% (85% de) of **27***R*. Partly separation of the diastereomers gave 88% (89% de) of **27***R* as a white solid; ^{1}H NMR δ 7.35–7.15 (m, Ar–*H*, 8H), 7.01 (dd, Ar–*H*, *J*=7.9, 1.7 Hz, 2H), 4.58 (m, N–C*H*, 1H), 4.12 (dd, CH_2O, *J*=8.5, 8.5 Hz, 1H), 4.06 (dd, CH_2O, *J*=8.5, 3.0 Hz, 1H), 3.50 (dd, CH_2CH, *J*=16.1, 8.5 Hz, 1H), 3.24 (m, C*H*CH$_2$, 1H), 3.09 (dd, CH_2CH, *J*=16.1, 6.1 Hz, 1H), 2.98 (dd, CH_2Ph, *J*=13.6, 3.2 Hz, 1H), 2.50 (dd, CH_2Ph, *J*=13.6, 9.3 Hz, 1H), 1.74–1.62 (m, alkyl-CH_2, 2H), 1.35–1.09 (m, alkyl-CH_2, 4H), 0.83 (t, CH_3CH$_2$, *J*=7.1 Hz, 3H); ^{13}C NMR δ 172.3, 153.6, 144.4, 135.3, 129.6, 129.1, 128.6, 128.0, 127.4, 126.6, 66.1, 55.1, 42.1, 42.1, 37.7, 36.4, 29.8, 22.8, 14.2; FTIR (film, cm^{-1}) 1781, 1700; HRMS (EI) calcd for $C_{23}H_{27}NO_3$ 365.1991, found 365.1996.

4.5.38. *N*-(3′*S*-Phenylheptanoyl)-4*S*-phenylmethyl-1,3-oxazolidin-2-one (27*S*). Obtained from the reaction of imide **7** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in hexanes; R_f 0.35) to give 87% (75% de) of **27***S* as colorless syrup; ^{1}H NMR δ 7.33–7.21 (m, Ar–*H*, 7H), 7.20–7.14 (m, Ar–*H*, 3H), 4.47 (m, N–C*H*, 1H), 4.05 (dd, CH_2O, *J*=9.0, 2.6 Hz, 1H), 3.96 (dd, CH_2O, *J*=9.0, 9.0 Hz, 1H), 3.38 (dd, CH_2CH, *J*=15.3, 7.9 Hz, 1H), 3.24 (m, C*H*CH$_2$, 'partly hidden,' 1H), 3.22–3.18 (m, CH_2Ph and CH_2CH, 'partly hidden,' 2H), 2.65 (dd, CH_2Ph, *J*=13.4, 9.9 Hz, 1H), 1.76–1.63 (m, CH_2CH, 2H), 1.38–1.09 (2m, alkyl chain, 4H), 0.84 (t, CH_3CH$_2$, *J*=7.3 Hz, 3H); ^{13}C NMR δ 172.2, 153.6, 144.4, 135.6, 129.6, 129.1, 128.5, 127.9, 127.5, 126.6, 66.3, 55.4, 42.3, 42.1, 38.0, 36.5, 29.8, 22.8, 14.1; FTIR (film, cm^{-1}) 1781, 1699; HRMS (EI) calcd for [$C_{23}H_{27}NO_3$] 365.1991, found 365.1988.

4.5.39. *N*-(3′*R*-Phenylheptanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (28*R*). Obtained from the reaction using imide **8** and PhCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.35 on silica gel) to give 92% (89% de) of **28***R* as a colorless syrup; ^{1}H NMR δ 7.30–7.06 (m, Ar–*H*, 20H), 4.22 (N–C*H*, 1H), 3.42 (dd, CH_2O, *J*=9.8, 4.0 Hz, 1H), 3.37 (dd, CH_2CH, *J*=16.1, 8.1 Hz, 1H), 3.07 (m, C*H*–Ph, 'partly hidden,' 1H), 3.04 (dd, CH_2O, *J*=9.8, 2.7 Hz, 'partly hidden,' 1H), 3.01 (dd, CH_2CH, *J*=16.1, 5.6 Hz, 1H), 2.78 (ddd, α-CH_2CH$_2$, *J*=17.9, 11.0, 10.1 Hz, 1H), 2.34 (ddd, α-CH_2CH$_2$, *J*=17.9, 9.3, 2.4 Hz, 1H), 1.80 (m, CH_2CH$_2$-ring, 2H), 1.60 (m, CH_2CH$_2$-chain, 2H), 1.27–1.10 (m, CH_2CH$_2$-chain, 'partly hidden,' 2H), 1.14–0.99 (2m, CH_2CH$_2$-chain, 1H each), 0.76 (t, CH_3CH$_2$, *J*=7.1 Hz,

3H); ^{13}C NMR δ 176.4, 172.8, 145.0, 143.9, 128.8, 128.4, 128.1, 128.0, 127.3, 126.3, 87.2, 64.2, 56.9, 44.0, 41.7, 36.5, 33.3, 29.9, 22.8, 21.3, 14.2; FTIR (film, cm^{-1}) 1734, 1692; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{34}H_{39}NO_3Na]^+$ 568.2828, found 568.2855.

4.5.40. *N*-(3′*S*-Phenylheptanoyl)-5*S*-triphenylmethoxymethyl-2-pyrrolidinone (28*S*). Obtained from the reaction using cinnamate **12** and BuCu(LiI)TMSI. The crude product was purified using flash chromatography (30% Et_2O in pentane; R_f 0.35 on silica gel) to give 93% (93% de) of **28*S*** as a colorless syrup; ^{1}H NMR δ 7.24–7.06 (m, Ar–*H*, 20H), 4.31 (m, N–C*H*, 1H), 3.29 (dd, CH_2O, *J*=9.8, 4.1 Hz, 1H), 3.21 (dd, CH_2CH, *J*=16.4, 7.4 Hz, 1H), 3.15 (dd, CH_2CH, *J*=16.4, 6.6 Hz, 1H), 3.08 (m, C*H*–Ph, 1H), 2.99 (dd, CH_2O, *J*=9.8, 2.5 Hz, 1H), 2.74 (ddd, α-CH_2CH$_2$, *J*=18.1, 11.1, 9.9 Hz, 1H), 2.34 (ddd, α-CH_2CH$_2$, *J*=18.1, 9.9, 1.4 Hz, 1H), 1.94 (m, CH_2-ring, 1H), 1.78 (m, CH_2-ring, 1H), 1.64–1.48 (2m, CH_2, 1H each), 1.90–1.20 (m, 2×CH_2, 4H), 0.74 (t, CH_3CH$_2$, *J*=6.8 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.8, 172.9, 145.0, 143.8, 128.7, 128.5, 128.0, 127.9, 127.3, 126.3, 87.2, 63.9, 56.9, 44.0, 41.5, 36.4, 33.3, 29.8, 22.8, 21.5, 14.2; FTIR FTIR (film, cm^{-1}) 1734, 1693; HRMS (FAB DCM/NBA/NaCl) calcd for $[C_{34}H_{39}NO_3Na]^+$ 568.2828, found 568.2833.

4.5.41. *N*-(3′*R*-Phenylheptanoyl)-(4*S*,5*R*)-indano[1,2-*d*]-oxazolidin-2-one (29). Obtained from the reaction using imide **14** and BuCu(LiI) TMSI. Crude product was purified using flash chromatography (30% ether in pentane, R_f 0.30 on silica gel) to give 86% (95% de) of **29** as a clear oil. ^{1}H NMR δ 7.31–7.10 (m, Ar–*H*, 9H), 5.87 (d, NC*H*, *J*= 7.0 Hz, 1H), 5.23 (m, OC*H*, 1H), 3.41 (dd, COCH_2, *J*=16.0, 7.9 Hz, 1H), 3.34 (m, ArCH_2, 2H), 3.25 (m, ArC*H*, 1H), 3.15 (dd, COCH_2, *J*=16.0, 6.6 Hz, 1H), 1.69 (m, CH_2, 2H), 1.36–1.08 (m, 2×CH$_2$, 4H), 0.84 (t, CH_3CH$_2$, *J*=7.3 Hz, 3H); ^{13}C NMR δ 172.6, 153.1, 144.4, 139.4, 139.2, 129.8, 128.5, 128.3, 127.9, 127.2, 126.5, 125.2, 78.2, 63.1, 42.1, 41.9, 38.1, 36.2, 29.8, 22.8, 14.1; FTIR (film, cm^{-1}) 1782, 1698; HRMS (DEI) calc for $[C_{23}H_{25}NO_3]$ 363.1834, found 363.1842.

4.5.42. *N*-(3′*R*-Methylheptanoyl)-(4*S*,5*R*)-indano[1,2-*d*]-oxazolidin-2-one (30). Obtained from the reaction using imide **13** and BuCu(LiI) TMSI. The crude product was purified using flash chromatography (30% ether in pentane, R_f 0.40 on silica gel) to give 87% (90% de) of **30** as a clear oil; ^{1}H NMR δ 7.63 (d, Ar–*H*, *J*=7.7 Hz, 1H), 7.34 (m, Ar–*H*, 1H), 7.26 (m, Ar–*H*, 2H), 5.95 (d, NC*H*, *J*=6.9 Hz), 5.26, (m, OC*H*, 1H), 3.38 (m, ArCH_2, 2H), 2.86 (dd, COCH_2, *J*=17.9, 6.5 Hz, 1H), 2.83 (dd, COCH_2, *J*=17.9, 7.3 Hz, 1H), 2.08 (m, CH3C*H*, 1H), 1.42–1.18 (m, alkyl, 6H), 0.97 (d, CH_3CH, *J*=6.7 Hz, 3H), 0.89 (t, CH_3CH$_2$, *J*=6.7 Hz, 3H); ^{13}C NMR δ 173.5, 153.2, 139.7, 139.5, 130.0, 128.3, 127.4, 125.4, 78.1, 63.2, 42.5, 38.2, 36.6, 30.0, 29.3, 23.0, 19.9, 14.3; FTIR (film, cm^{-1}) 1781, 1698; HRMS (DEI) calc for $[C_{18}H_{23}NO_3]$ 301.1678, found 301.1675.

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