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A Single-Step Synthesis of 4-Oxazolin-2-ones and Their Use in the Construction of Polycyclic Structures Bearing Quaternary Stereocenters

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A new method for the synthesis of 4-oxazolin-2-ones by a one-pot MW-promoted condensation of α-ketols and isocyanates is reported. An alternative thermal approach using the same starting materials is also described. These cyclic enamides were efficient nucleophiles, reacting with Michael acceptors and prenyl bromide to give a variety of polycyclic structures bearing one or two quaternary stereocenters. The selectivity of the products depended on the reaction conditions and on the electrophile used.

Introduction

The synthetic potential of substituted 4-oxazolin-2-ones, 2-oxazolidinones, and 4-methylene-2-oxazolidinones as chiral auxiliaries, versatile intermediates, biologically active compounds, and β-amino alcohols precursors[1] has attracted special attention, leading to the development of a large number of synthetic methods for the preparation of these compounds.[2] They have also found widespread use in the fields of agriculture,[3] industry,[4] and pharmaceuticals.[5] 4-Oxazolin-2-ones can be considered as ambident nucleophiles[6] as they have two potential attacking atoms: The C-4 and C-5 atoms (Figure 1). The former results from the fact that it is the terminal carbon of the double bond of an enol ester moiety and the latter from the fact that it is the terminal carbon of the double bond of an enamide moiety.[7] In principle, under electrophilic conditions, either one or both centers may attack the electrophile. To the best of our knowledge, 4-oxazolin-2-ones have been little studied as nucleophilic species for the synthesis of attractive molecular targets.[7,8] The reason for this is that enamides have been regarded as deactivated enamines lacking the nucleophilic reactivity characteristic of the latter.

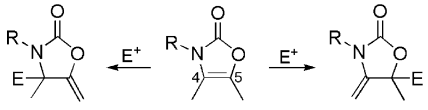

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Figure 1. Compounds **1** as potential ambident nucleophiles.

Previously, we designed a regioselective synthesis of *N*-substituted 4-oxazolin-2-ones **1** and 4-methylene-2-oxazolidinones **2** starting from α-ketol **3a** and isocyanates **4** (Scheme 1).[9] The one-pot synthesis of 4-methylene-2-oxazolidinones **2** involved a tandem condensation of **3a** with a series of isocyanates **4**; the presence of dioxane as solvent was essential to yield this regioisomer.[9] In contrast, when DMF was employed as the solvent, a stereoisomeric mixture of aminals **5** was obtained, which were treated thermally in the presence of DMSO to give a series of thermodynamic isomers of 4-oxazolin-2-ones **1**. This methodology was also efficient for the preparation of the corresponding 3-substituted 4-oxazoline-2-thiones **6** and 4-methylene-1,3-oxazolidine-2-thiones **7** (Scheme 1).[10] Although obtained in lower yields, compounds **6** were also prepared by an alternative single-step reaction by microwave (MW) irradiation of a mixture of **3a** and **8**.[10] We also found that compounds **1** behave as neutral nucleophiles in the presence of a Michael acceptor, leading to the addition product at C-5 with the regioselectivity totally controlled by the enamide moiety.[9]

As a part of our ongoing research into the synthesis of 4-oxazolin-2-ones and their potential as nucleophiles, we herein describe a short and efficient method for the synthe-

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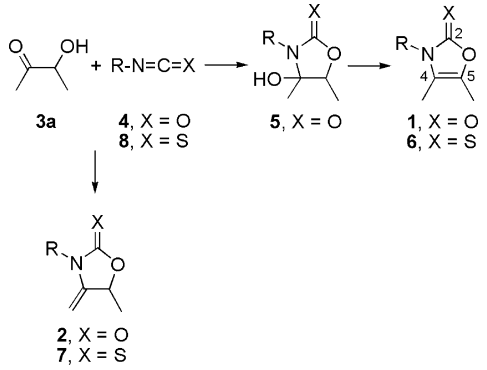
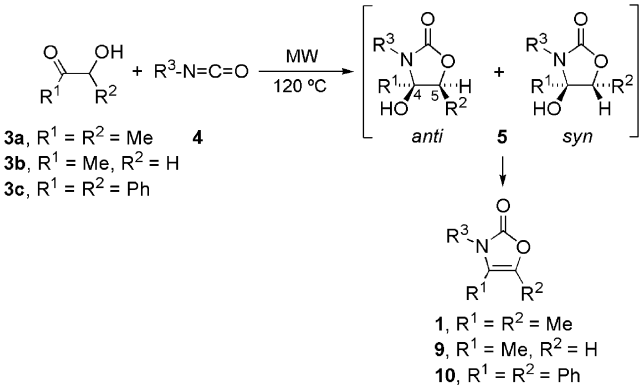


Scheme 1.



Scheme 2.

sis of these heterocycles as well as their use in the construction of a variety of substituted bicyclic structures with quaternary stereocenters.[11]

Results and Discussion

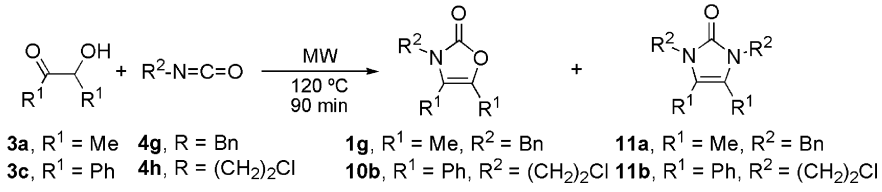
Following the successful preparation of the 4-oxazoline-2-thiones **6** by MW irradiation of a mixture of **3a** and isothiocyanates **8**,[10] we undertook the synthesis of the 4-oxazolin-2-ones **1** by the same methodology, but by using isocyanates **4a**–**g** as the starting materials (Scheme 2). Unlike compounds **6**, which required 2 mol-equiv. of triethylamine, a number of derivatives **1** were obtained in high yields in the absence of base (Table 1, entries 1–8). Note that in contrast to the previously reported method,[9] which required solvent and was carried out in a two-step sequence, this was a solvent-free single-step procedure. Moreover, this new method provides, except in the case of **1h**, much higher yields (ca. 77%) than the previous one (ca. 58%). In addition, the isolation procedure was very simple as the crude mixture was dissolved in dichloromethane and then poured into water. The organic layer was then dried, the solvent removed, and the solid residue recrystallized. Interestingly, when the reaction was carried out with benzyl isocyanate (**4g**), a second product was isolated in 21% yield, the *N*,*N*′-disubstituted 1,3-imidazol-2-one **11a** (Scheme 3). This was probably formed as a result of the presence of benzylamine in the reaction mixture which adds to **1g**.[4b,12] The amine would result from the hydrolysis of the isocyanate by water liberated in the reaction.

Table 1. Yields of compounds **1a**–**h**, **9a**–**c**, and **10a**,**b** obtained by condensation of α-ketols **3a**–**c** with isocyanates **4**.[a]

Entry	Ketol	R^1	R^2	**4** (R^3)	Product (% yield)[b]
1	**3a**	Me	Me	**4a** (C_6H_5)	**1a** (92)
2	**3a**	Me	Me	**4b** (4-MeC_6H_4)	**1b** (80)
3	**3a**	Me	Me	**4c** (2-$OMeC_6H_4$)	**1c** (72)
4	**3a**	Me	Me	**4d** (4-$OMeC_6H_4$)	**1d** (62)
5	**3a**	Me	Me	**4e** (4-ClC_6H_4)	**1e** (84)
6	**3a**	Me	Me	**4f** (3-$OMeC_6H_4$)	**1f** (65)
7	**3a**	Me	Me	**4g** ($C_6H_5CH_2$)	**1g** (79)
8	**3a**	Me	Me	**4h** ($ClCH_2CH_2$)	**1h** (31)
9	**3b**	Me	H	**4a** (C_6H_5)	**9a** (78)
10	**3b**	Me	H	**4d** (4-$OMeC_6H_4$)	**9b** (80)
11	**3b**	Me	H	**4i** (3-MeC_6H_4)	**9c** (78)
12	**3c**	Ph	Ph	**4a** (C_6H_5)	**10a** (81)
13	**3c**	Ph	Ph	**4h** ($ClCH_2CH_2$)	**10b** (50)

[a] In the presence of 1:1 mol-equiv. of **3**/**4**; MW irradiation (200 W), 120 °C, 90 min. [b] Yield after recrystallization or column chromatography.

The versatility of the method was also tested with α-ketols **3b** and **3c**. The reaction of the former with isocyanates **4a**, **4d**, and **4i** led to the corresponding 3-substituted 1,3-oxazolin-2-ones **9a**–**c** in good yields (Table 1, entries 9–11). Microwave irradiation of mixtures of **3c** with isocyanates **4a** or **4h** gave the expected heterocycles **10a**,**b** in modest-to-good yields (Table 1, entries 12 and 13). In the case of **10b**, a small amount (6%) of the 1,3-imidazol-2-one **11b** was also isolated (Scheme 3). The structure of **10b** was established by spectroscopy and confirmed by X-ray crystallography (Figure 2).[13] The planes of the phenyl groups are almost orthogonal, with the 5-Ph group being close to being coplanar with the heterocycle. This conformation is probably stabilized by hydrogen-bonding as the *ortho* proton (C7-H) of



Scheme 3.

5-Ph points towards the *ipso*-C of the 4-Ph group, with a distance between them (2.695 Å) indicative of a CH···π interaction.

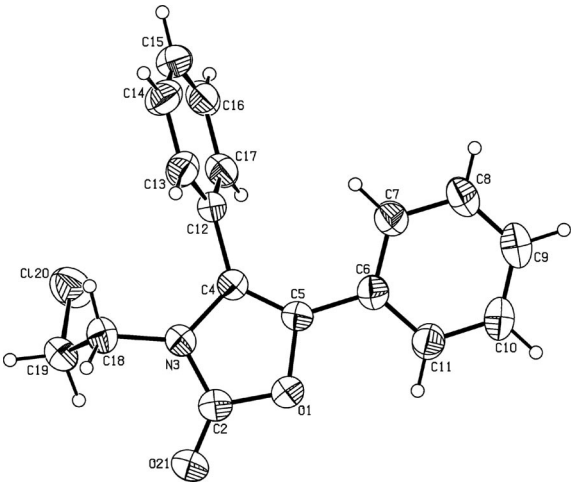
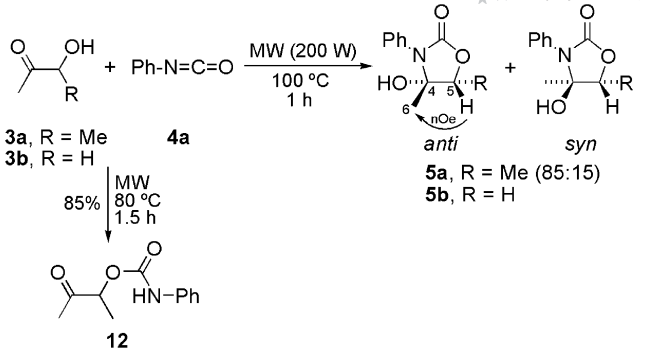


Figure 2. X-ray structure of **10b** (ellipsoids at the 30% probability level).

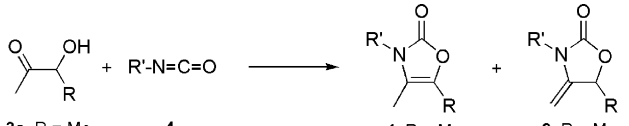
In addition, the MW procedure allows the selective formation of hemiaminals **5** (Scheme 4) as the reaction of **3a** and **4a** carried out at a lower temperature (100 °C) furnished a mixture of the stereoisomeric hemiaminals **5a** (*anti*/*syn*, 85:15) in good yield (78%). The structure of the major isomer *anti*-**5a** was established by NOE experiments in which the signal of the 6-Me group is enhanced on irradiation of the 5-H signal. When a mixture of α-ketol **3b** and **4a** was allowed to react under the same conditions, hemiaminal **5b** was formed in 80% yield (Scheme 4). It was interesting to find that no hemiaminals **5a** were obtained when the reaction between **3a** and **4a** was carried out under MW irradiation at a lower temperature (80 °C) and that only carbamate **12** was isolated in high yield as colorless crystals (Scheme 4).



Scheme 4.

These results support not only the previously proposed mechanism for the formation of compounds **1**,[9] but also the idea that the sequential processes, the cyclization step of carbamates **12** to hemiaminals **5** and the conversion of the latter, by dehydration, to the desired 1,3-oxazolin-2-ones **1**, are thermally dependent. Therefore, we investigated the transformation of a mixture of α-ketols **3** and isocyanates **4** into the desired 4-oxazolin-2-ones **1** under thermal conditions in the absence of solvent. When α-ketol **3a** was treated with **4a** at 140 °C for 36 h, the expected 4-oxazolin-2-one **1a** was obtained in excellent yield (Table 2, entry 1). The reaction with isocyanate **4h** furnished the corresponding heterocycle **1h** in moderate yield (Table 2, entry 7). To shorten the reaction time, triethylamine was added (1.2 mol-equiv.) to the reaction mixture, which gave **1a** as the major product in high yield (85%; entry 2). In addition, a second product was isolated, which corresponded to the 4-methylene-2-oxazolidinone **2a**, in low yield (12%). In contrast with the results obtained with isocyanate **4h**, in the reactions of **3a** with isocyanates **4d** and **4e**, larger amounts of the isomers with the exocyclic double bond, **2d** and **2e**, were obtained (Table 2, entries 4 and 5). As shown previously, because the latter isomer is the kinetic product,[9] it

Table 2. Thermal condensation of α-ketols **3a** and **3b** with isocyanates **4**.[a]



Entry	**3**	**4** (R^3)	Et_3N [mol-equiv.]	*T* [°C]	*t* [h]	**1** (% yield)[b]	**2** (% yield)[b]
1	**3a**	**4a** (C_6H_5)	–	140	36	**1a** (97)	**2a** (0)
2	**3a**	**4a** (C_6H_5)	1.2	130	24	**1a** (85)	**2a** (12)
3	**3a**	**4b** (4-MeC_6H_4)	1.2	110	24	**1b** (39)	**2b** (49)
4	**3a**	**4d** (4-$OMeC_6H_4$)	1.2	130	24	**1d** (43)	**2d** (31)
5	**3a**	**4e** (4-ClC_6H_4)	1.2	130	24	**1e** (30)	**2e** (17)
6	**3a**	**4f** (3-$OMeC_6H_4$)	1.2	110	24	**1f** (49)	**2f** (26)
7	**3a**	**4h** ($ClCH_2CH_2$)	–	130	24	**1h** (55)	**2h** (0)
8	**3b**	**4a** (C_6H_5)	–	130	24	**9a** (83)	**2a** (0)
9	**3b**	**4a** (C_6H_5)	1.2	130	24	**9a** (66)	**13a** (0)
10	**3b**	**4i** (3-MeC_6H_4)	–	130	24	**9c** (84)	**2h** (0)
11	**3b**	**4i** (3-MeC_6H_4)	1.2	130	24	**9c** (75)	**13b** (0)

[a] In the presence of 1:1.2 mol-equiv. of **3a/4**. [b] Yield after recrystallization or column chromatography.

is expected that decreasing the temperature would increase the proportion of compounds **2** to the detriment of the thermodynamic compounds **1**. Indeed, although the conversion of starting materials was not complete, in the reactions of **3a** with isocyanates **4b** and **4f** carried out at 110 °C, the proportion of isomers **2** was augmented (Table 2, entries 3 and 6). If the temperature was further decreased, hemiaminals **5** started to appear in the reaction mixtures.

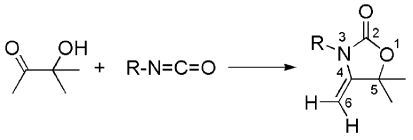
In contrast to this behavior, when α-ketol **3b** was submitted to reaction with isocyanates **4a** and **4i** under both conditions, either with or without triethylamine, only the isomers with the endocyclic double bond, **9a** and **9c**, were obtained (Table 2, entries 8–11), that is, even in the crude mixtures, 4-methylene-2-oxazolidinones **2a**, **2h**, **13a**, and **13b** were not detected.

Furthermore, this methodology proved to be efficient with tertiary α-ketol **3d**. The reaction between **3d** and **4a** led to the 4-methylene-1,3-oxazolidin-2-one **14a** in moderate yield (Table 3, entry 1). However, to obtain the latter, the power of the MW irradiation, the temperature, and the reaction time had to be increased compared with the reactions with α-ketols **3a**–**c**. In contrast, **14a** was obtained in a higher yield when the condensation reaction was carried out under thermal and solvent-free conditions (Table 3, entry 2). These conditions were later extended to the reactions of **3d** with isocyanates **4d** and **4h**, which afforded 4-methylene-1,3-oxazolidin-2-ones **14b** and **14c**, respectively (Table 3, entries 3 and 4). X-ray diffraction analysis of **14b** showed a structural pattern (Figure 3)[13] similar to other analogous heterocycles,[9,10,14] namely the quasi-orthogonal conformation of the aromatic ring attached to the nitrogen atom with respect to the heterocyclic ring.

Owing to the fact that any methodology that is able to introduce quaternary stereocenters into the target molecules attracts great interest in organic synthesis[15] because of the large incidence of natural products containing this structural attribute, it is important that the heterocycles **14** obtained possess a quaternary stereocenter at C-5 (see below).

The Michael reaction is a powerful tool for the formation of C–C bonds and the β-functionalization of carbonyl compounds.[16] As we have previously shown, 4-oxazolin-2-one **1a** undergoes conjugate addition to methyl vinyl ketone (**15a**) under thermal conditions (160 °C) to give adduct **16a** (Scheme 5).[9] We investigated more drastic thermal conditions and MW irradiation with the aim of evaluating the

Table 3. Yields of compounds **14a**–**c**, obtained by condensation of α-ketol **3d** and isocyanates **4**.[a]



Entry	**4** (R)	**14** (% yield)[b]
1[c]	**4a** (C_6H_5)	**14a** (67)
2[d]	**4a** (C_6H_5)	**14a** (86)
3[d]	**4d** (4-$OMeC_6H_4$)	**14b** (92)
4[e]	**4h** ($ClCH_2CH_2$)	**14c** (53)

[a] In the presence of ca. 1:1.2 mol-equiv. of **3d**/**4**. [b] Yield after recrystallization or column chromatography. [c] MW irradiation (300 W), 140 °C, 3 h. [d] Carried out at 130 °C, no solvent, 24 h. [e] Carried out with 1.0 mol-equiv. of Et_3N, at 130 °C, no solvent, 36 h.

reactivity of the enamide scaffold of **1** with other electrophiles, as well as that of the newly formed exocyclic enamide moiety of **16a**. Thus, thermal treatment of a mixture of **1a** and **15a** at 160 °C for 24 h gives rise not only to adduct **16a** in 59% yield, but also to endocyclic diene **19a** in low yield (14%; Scheme 5). The presence of the latter indicates that the enamide moiety of **16a** is able to add to the carbonyl group intramolecularly through the sequential formation of the zwitterionic intermediate **17a** and then alcohol **18a**, which undergoes dehydration to diene **19a**.

A Lewis acid such as $AlCl_3$ catalyzed the same reaction at a lower temperature (70 °C) to give adduct **16a** (42%) and a slightly improved yield of diene **19a** (36%). However, when the thermal reaction was carried out at 160 °C in the presence of $ZnCl_2$ in acetonitrile, diarylamine **20a** was isolated as the main product in low yield (35%; Scheme 5). Compounds **16a** and **19a** were not observed in the reaction mixture, but unidentified side-products were detected. Diarylamine **20a** may arise from decarboxylation and aromatization of diene **19a**, as has previously been suggested.[9] This mechanism is supported by the fact that adduct **16a** was converted into diarylamine **20a** in 49% yield when it was treated under the same conditions.

To improve the selectivity and yields of these processes, we investigated the use of MW irradiation in the conjugate addition of **1a** to **15a**. Thus, after MW irradiation (300 W, 140 °C) of a solvent-free mixture of **1a** and **15a**, adduct **16a**

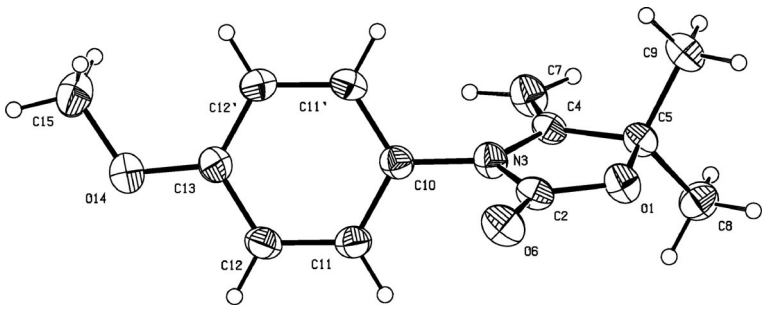
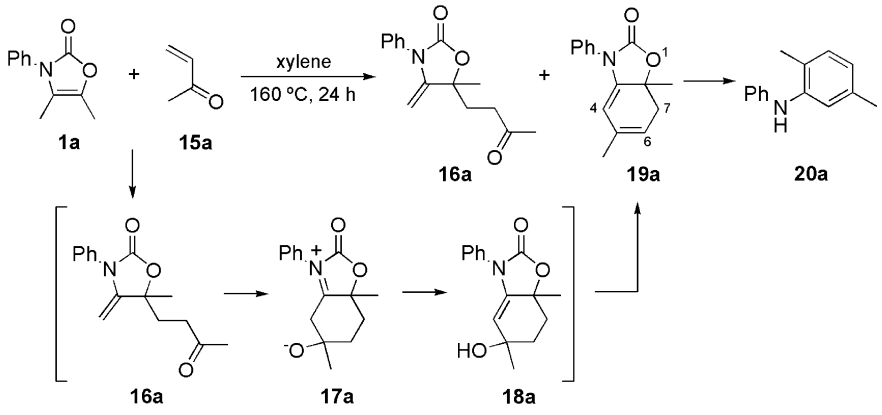
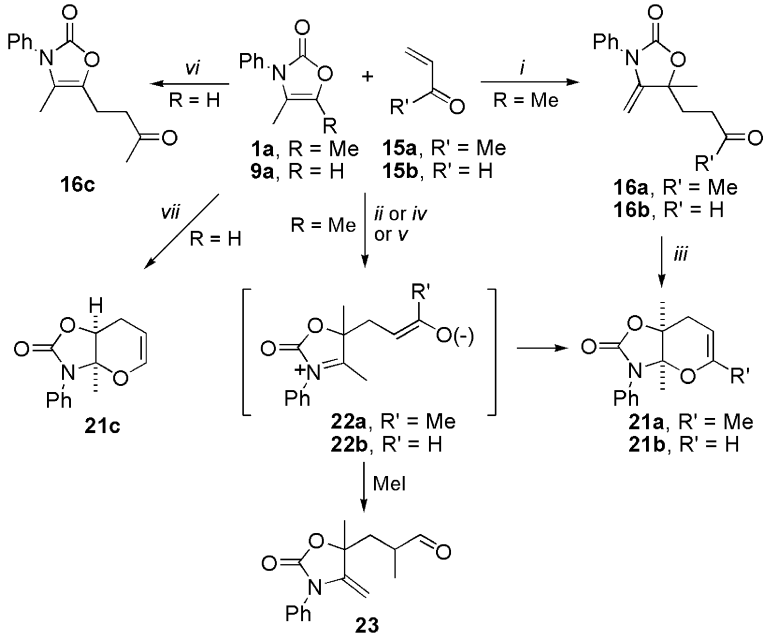


Figure 3. X-ray structure of **14b** (ellipsoids at the 30% probability level).



Scheme 5.



Scheme 6. Reagents and conditions: (*i*) **1a** and **15a**, MW (300 W), 140 °C, 6 h: **16a** (77%) and **21a** (16%); (*ii*) **1a** and **15a**, MW (400 W), 160 °C, 6 h: **21a** (34%); (*iii*) **16a** and **15a**, MW (400 W), 160 °C, 4 h: **21a** (34%); (*iv*) **1a** and **15b**, MW (200 W), 100 °C, 6 h: **21b** (77%); (*v*) **1a** and **15b**, 80 °C, 5 d: **21b** (81%); (*vi*) **9a** and **15a**, 160 °C, 24 h: **16c** (87%); (*vii*) **9a** and **15b**, 100 °C, 24 h: **21c** (74%).

was obtained in 77% yield, along with the bicyclic dihydropyran **21a** (16%; Scheme 6). When the power of the irradiation and the temperature were increased to 400 W and 160 °C, respectively, compound **21a** was afforded in a higher yield (34%). Although dihydropyrans can be prepared by concerted hetero-Diels–Alder cycloaddition between enamines and oxabutadienes,[17] **21a** can be synthesized by a stepwise mechanism, as suggested in a previous report.[18] It is well known that MW irradiation promotes the activation and stabilization of polar species.[19] Hence it could stabilize zwitterionic intermediate **22a** to allow cyclization to compound **21a** by attack of the charged oxygen atom on the electrophilic iminium carbon atom (Scheme 6). To support this idea, adduct **16a** was treated under analogous conditions. Thus, MW irradiation (400 W, 160 °C) for 4 h, led to isolation of the dihydropyran **21a** in 34% yield.

These interesting results prompted us to investigate the addition of **1a** to a more reactive Michael acceptor such as acrolein (**15b**). Therefore, when a mixture of the latter was irradiated (200 W) at 100 °C for 6 h in the presence of **1a**, only dihydropyran **21b** was observed in good yield (77%; Scheme 6). The structure of **21b** was established by spectroscopy and X-ray crystallography (Figure 4).[13] A similar result was obtained when the mixture was heated at 80 °C for 5 d; **21b** was obtained in 81% yield. All thermal or MW assays carried out to isolate **16b** were unsuccessful. This contrasting behavior of **15b** in comparison with **15a** indicates that the reactivity of the zwitterionic species **22b** is higher than that of **22a**, which is probably due to the lower stability of the monosubstituted enolate moiety of **22b**. This hypothesis seems to be supported by the fact that **16c** was obtained and isolated in high yield (87%) when the reaction between **9a** and **15a** was carried out under thermal conditions (160 °C, 24 h). Further evidence for this is provided by the thermal reaction of **9a** with **15b** under less severe conditions, which gave the dihydropyran **21c** in good yield (74%; Scheme 6).

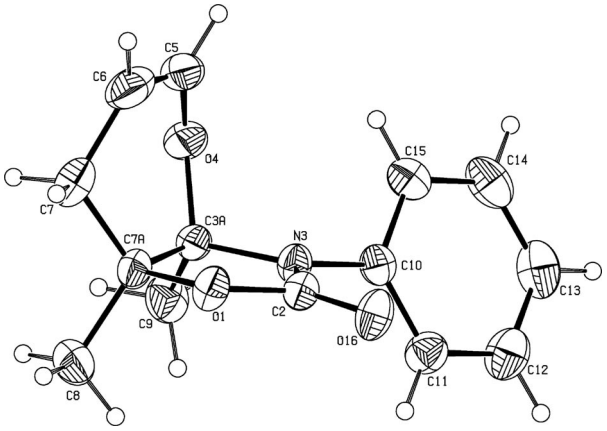
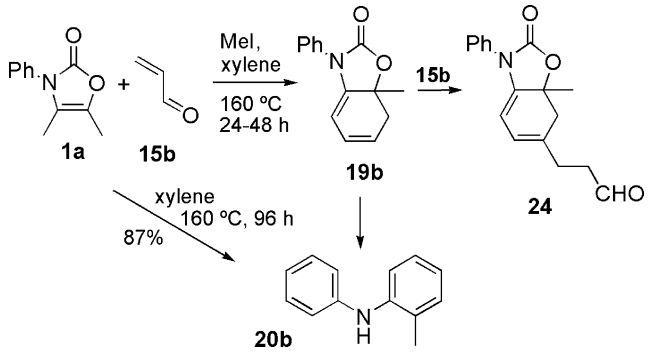


Figure 4. X-ray structure of **21b** (ellipsoids at the 30% probability level).



Scheme 7.

Although a formal concerted hetero-Diels–Alder addition cannot be completely ruled out in the formation of dihyropyrans **21**, we tried to capture enolate **22b** by adding a reactive electrophile such as methyl iodide to give **23** (Scheme 6). Thus, when a mixture of **1a** and an excess (3 mol-equiv.) of **15b** was heated in xylene at 160 °C in the presence of 2.0 mol equiv. of MeI, diene **19b** was isolated as a single product in 93% yield (Scheme 7). Even when the reaction temperature was decreased (100–120 °C), the methylated quenching product **23** was not detected by ^{1}H NMR measurements of the crude mixture. However, by lowering the temperature, the dihydropyran **21b** was observed in the reaction mixture, which suggests that it corresponds to the kinetic product, whereas the diene **19b** corresponds to the thermodynamically controlled product.

To obtain more insight into this reaction, we carried out the addition reaction of **1a** with a large excess (5 mol-equiv.) of **15b** in xylene at 160 °C in the presence of MeI (2.0 mol-equiv.) for 24 h. Diene **19b** was obtained and, in contrast with the reactions shown in Scheme 5 in which aniline **20a** was isolated as the main product under these conditions, aniline **20b** was not detected (Scheme 7). The role that methyl iodide plays in the reaction is still not clear, but it seems to be significant because when the reaction was conducted in the absence of MeI, diene **19b** was obtained in low yield (30%) or the corresponding aniline **20b** was afforded. Probably, methyl iodide was reduced to iodine, which activated acrolein (**15b**) by complexing the oxygen atom or the double bond as a Lewis acid catalyst, as has been documented previously.[20] A similar complexing function of iodine with the carbonyl group of intermediate **16b** would favor nucleophilic attack of the exocyclic enamide to give diene **19b**. In fact, a similar outcome resulted when the addition was carried out in the presence of iodine (5% mol-equiv.) at 0 °C for 2.5 h, albeit in low yield (31%). The structure of **19b** was established by spectroscopy and X-ray crystallography (Figure 5).[13]

It was interesting that other products could be isolated depending on the reaction time, the presence of methyl iodide, or the number of mol-equiv. of **15b**. For example, when further mol-equiv. of **15b** were added, aside from diene **19b**, the major product of the reaction mixture corresponded to diene **24**, which arose from the conjugate addition of diene **19b** to a second molecule of **15b** (Scheme 7). Moreover, when the reaction without methyl iodide was maintained at 160 °C for 96 h, a different outcome was observed as phenyl(tolyl)amine **20b** prevailed over diene **19b** and was isolated in good yield (87%). Decarboxylation of the latter would explain the formation of **20b**.

Owing to the softness of the Michael acceptors used as electrophiles, and with the aim of extending the study of the reactivity of 4-oxazolin-2-ones **1** to diverse substrates, we explored the reaction of prenyl bromide (**25**) with **1a** (Scheme 8). Thermal (160 °C) treatment of a mixture of **1a** and **25** in xylene for 24 h gave, instead of the expected product **28**, the fused cyclohexenic oxazolidine **26** in moderate yield (53%) as colorless crystals. The structure was assigned

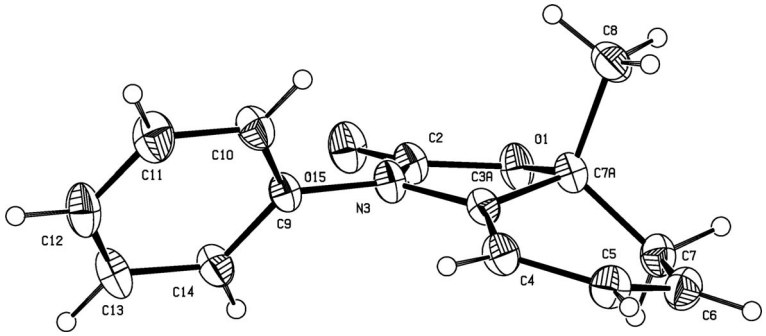
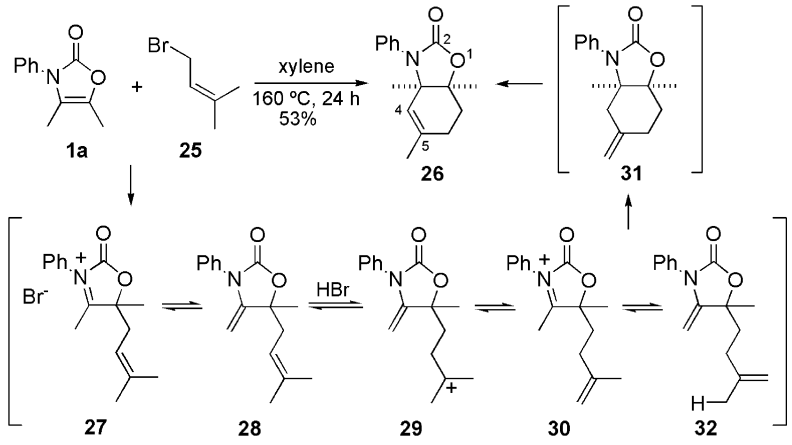


Figure 5. X-ray structure of **19b** (ellipsoids at the 30% probability level).



Scheme 8.

by 1D and 2D NMR measurements and unambiguously established by single-crystal X-ray diffraction (Figure 6).[13] Note that both the fused heterocycle and cyclohexene rings adopt a twisted conformation, which allows the angular methyl groups to assume a more stable noneclipsed conformation. This could explain why the double bond is selectively formed at the C4–C5 position and not at the C5–C6 of the bicycle **26**, which facilitates such a twisted conformation.

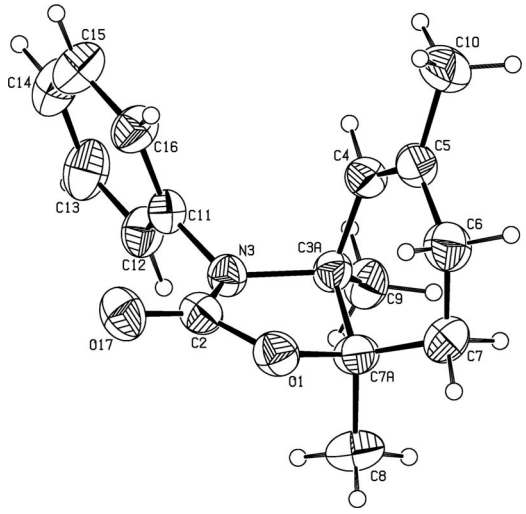


Figure 6. X-ray structure of **26** (ellipsoids at the 30% probability level).

Two possible domino mechanisms for this reaction can be proposed, as depicted in Scheme 8. Both involve a first prenylation reaction at the C-5 carbon atom to afford the salt **27**, which leads to the neutral species **28**. The double bond of the prenyl chain of the latter undergoes protonation to yield carbocation **29**, followed by isomerization to the iminium species **30** and ring closure to the cyclohexene intermediate **31**, and finally isomerization of the double bond to yield **26**. An alternative pathway starts from **28** to give, through isomerization of the double bond, neutral dialkene **32**, which undergoes an intramolecular ene reaction to yield precursor **31**,[21] and then isomerization to the observed cyclohexene product **26**. At least for the first step, these mechanisms may be supported by the fact that prenylated product **28** was isolated from the crude mixture in low yield (18%) when the reaction was carried out in xylene at 100 °C for 36 h.

Conclusions

We have described two methods for the one-step synthesis of *N*-substituted 4-oxazolin-2-ones **1** in high yields that involve thermal and MW irradiation conditions. These molecules have also proved to be reactive regioselective nucleophiles with a series of Michael acceptors, for example, methyl vinyl ketone (**15a**) and acrolein (**15b**), and alkyl bromides, such as prenyl bromide (**25**). Interestingly, and depending on the temperature, most of the reactions led to a variety of bicyclic molecules as a result of a domino process, taking advantage of the sequential formation of *endo*-heterocyclic enamides/*exo*-heterocyclic enamides or *endo*-heterocyclic enamides/iminium ions, either as nucleophilic/nucleophilic or nucleophilic/electrophilic species, respectively. In all cases, the regioselectivity of the reactions was controlled by the most nucleophilic center C-5 of the double bond of the 4-oxazolidin-2-ones **1**. Therefore these heterocyclic enamides are useful and versatile synthons for the preparation of a wide variety of functionalized heterocycles with quaternary carbon centers. Additional studies on the reactivity of these heterocycles and their application to the synthesis of complex polycyclic molecules are in progress and will be reported in due course.

Experimental Section

General: Melting points (uncorrected) were determined with an Electrothermal capillary melting point apparatus. IR spectra were recorded with a Perkin-Elmer 1600 spectrometer. ^{1}H and ^{13}C NMR spectra were obtained with a Varian Mercury-300 (300 MHz) instrument with $CDCl_3$ as the solvent and TMS as the internal standard. Mass spectra (MS) were recorded, in electron impact mode, with Hewlett–Packard 5971A and Thermo-Finnigan Polaris Q spectrometers. High-resolution mass spectra (HRMS), in electron

impact and FAB$^+$ modes, were obtained with JEOL JSM-GCMateII and JMS-SX 102 spectrometers, respectively. X-ray crystallographic structures were obtained with Siemens P4 and Oxford XcaliburS diffractometers. Microwave (MW) irradiation was performed by using a SEV/MIC-1 (Mexico) MW reactor.[22] Microanalyses were performed by M-H-W Laboratories (Phoenix, AZ). All air- and moisture-sensitive reactions were carried out under nitrogen using oven-dried glassware. THF and xylene were freshly distilled from sodium and dichloromethane and MeCN from calcium hydride prior to use. Li_2CO_3 was dried overnight at 120 °C before use. Et_3N was distilled from NaOH. All other reagents were used without further purification.

General Procedures for the Preparation of *N*-Substituted 4-Oxazolin-2-ones 1a–h, 9a–c, and 10a,b

Method A: A mixture of α-ketol **3** (0.01 mol) and isocyanate **4** (0.01 mol) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and irradiated with MW irradiation (200 W) at 120 °C for 90 min (see Table 1). The mixture was diluted with CH_2Cl_2 (40 mL), poured into H_2O (100 mL), and stirred for 30 min. The mixture was filtered and the aqueous layer was washed with CH_2Cl_2 (2 × 40 mL). The combined organic layers were dried (Na_2SO_4) and the solvent removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per gram of crude, hexane/EtOAc, 9:1) to give the corresponding heterocycles **1a**–**h**, **9a**–**c**, or **10a**,**b**.

Method B: A mixture of α-ketol **3** and isocyanate **4** (1.2 mol-equiv.) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and heated at 130–140 °C for 24–36 h. The mixture was diluted with CH_2Cl_2 (20 mL), stirred for 30 min, filtered, and the solvent removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per gram of crude, hexane/EtOAc, 9:1) to give the corresponding heterocycles **1**, **2**, or **9**.

Method C: Following the same procedure as described for method B with α-ketol **3b** and isocyanate **4** (1.2 mol-equiv.), triethylamine (1.2 mol-equiv.) was added and the corresponding heterocycles **1**, **2**, or **9** were obtained.

4,5-Dimethyl-*N*-phenyl-4-oxazolin-2-one (1a) and 5-Methyl-4-methylene-*N*-phenyl-2-oxazolidinone (2a): Synthesized according to method A, with **3a** (0.88 g) and **4a** (1.19 g), **1a** (1.73 g, 92%) was afforded. Synthesized according to method B, with **3a** (0.50 g, 5.67 mmol) and **4a** (0.81 g, 6.81 mmol), **1a** (1.04 g, 97%) was afforded. Synthesized according to method C, with **3a** (0.30 g, 3.40 mmol), **4a** (0.49 g, 4.09 mmol), and Et_3N (0.41 g, 4.09 mmol), **1a** (0.55 g, 85%) as colorless crystals (hexane/CH_2Cl_2, 1:1) and **2a** (0.077 g, 12%) as a pale-yellow powder were afforded. Data for **1a**: R_f = 0.50 (hexane/EtOAc, 7:3); m.p. 79–80 °C (ref.[9] 79–80 °C). Data for **2a**: R_f = 0.65 (hexane/EtOAc, 7:3); m.p. 87–88 °C (ref.[9] 87–88 °C).

4,5-Dimethyl-*N*-(4-tolyl)-4-oxazolin-2-one (1b) and 5-Methyl-4-methylene-*N*-(4-tolyl)-2-oxazolidinone (2b): Synthesized according to method A, with **3a** (0.88 g) and **4b** (1.33 g), **1b** (1.62 g, 80%) was afforded. Synthesized according to method C, with **3a** (0.20 g, 2.27 mmol), **4b** (0.36 g, 2.72 mmol), and Et_3N (0.28 g, 2.72 mmol), **1b** (0.18 g, 39%) as colorless crystals (hexane/CH_2Cl_2, 1:1) and **2b** (0.23 g, 49%) as a pale-yellow powder were afforded. Data for **1b**: R_f = 0.61 (hexane/EtOAc, 7:3); m.p. 67–68 °C (ref.[9] 64–65 °C). Data for **2b**: R_f = 0.67 (hexane/EtOAc, 7:3); m.p. 72–73 °C (ref.[9] 72–73 °C).

***N*-(2-Anisyl)-4,5-dimethyl-4-oxazolin-2-one (1c):** Synthesized according to method A, with **3a** (0.88 g) and **4c** (1.49 g), **1c** (1.58 g, 72%) was afforded as colorless crystals (hexane/CH_2Cl_2, 6:1). R_f = 0.28 (hexane/EtOAc, 7:3); m.p. 112–113 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.72 (br. s, 3 H, CH_3C-4), 2.09 (br. s, 3 H, CH_3C-5), 3.82 (s, 3 H, MeO), 6.98–7.06 (m, 2 H, Ar-H), 7.21–7.26 (m, 1 H, Ar-H), 7.35–7.42 (m, 1 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 8.0 (*C*H_3C-4), 10.0 (*C*H_3C-5), 55.6 (O*C*H_3), 112.1 (arom. *C*H), 119.0 (C-4), 120.9 (arom. *C*H), 122.2 (arom. C), 129.9 (arom. *C*H), 130.4 (arom. *C*H), 131.6 (C-5), 154.6 (C-2), 155.6 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 1752, 1706, 1601, 1509, 1462, 1383, 1287, 1254, 1020, 985, 755, 697 cm^{-1}. MS (70 eV): *m*/*z* (%) = 219 (34) [M]$^+$, 148 (100), 133 (10), 92 (11), 77 (15). $C_{12}H_{13}NO_3$ (219.24): calcd. C 65.74, H 5.98, N 6.39; found C 66.09, H 6.13, N 6.68.

***N*-(4-Anisyl)-4,5-dimethyl-4-oxazolin-2-one (1d) and *N*-(4-Anisyl)-5-methyl-4-methylene-2-oxazolidinone (2d):** Synthesized according to method A, with **3a** (0.88 g) and **4d** (1.49 g), **1d** (1.36 g, 62%) was afforded as a white powder. Synthesized according to method C, with **3a** (0.20 g, 2.27 mmol), **4d** (0.41 g, 2.72 mmol), and Et_3N (0.28 g, 2.72 mmol), **1d** (0.21 g, 43%) and **2d** (0.15 g, 31%) as pale-yellow powders were afforded. Data for **1d**: R_f = 0.40 (hexane/EtOAc, 7:3); m.p. 76–77 °C (ref.[9] 76–77 °C). Data for **2d**: R_f = 0.58 (hexane/EtOAc, 7:3); m.p. 90–91 °C (ref.[9] 77–78 °C).

***N*-(4-Chlorophenyl)-4,5-dimethyl-4-oxazolin-2-one (1e) and *N*-(4-Chlorophenyl)-5-methyl-4-methylene-2-oxazolidinone (2e):** Synthesized according to method A, with **3a** (0.88 g) and **4e** (1.49 g), **1e** (1.87 g, 84%) was afforded as a white powder. Synthesized according to method C, with **3a** (0.30 g, 3.40 mmol), **4e** (0.63 g, 4.08 mmol), and Et_3N (0.41 g, 4.08 mmol), **1e** (0.23 g, 30%) and **2e** (0.13 g, 17%) as pale-yellow powders were afforded. Data for **1e**: R_f = 0.32 (hexane/EtOAc, 7:3); m.p. 132–133 °C (ref.[9] 125–126 °C). Data for **2e**: R_f = 0.52 (hexane/EtOAc, 7:3); m.p. 102–103 °C (ref.[9] 102–103 °C).

***N*-(3-Anisyl)-4,5-dimethyl-4-oxazolin-2-one (1f) and *N*-(3-Anisyl)-5-methyl-4-methylene-2-oxazolidinone (2f):** Synthesized according to method A, with **3a** (0.88 g) and **4f** (1.49 g), **1f** (1.42 g, 65%) was afforded as a white powder. Synthesized according to method C, with **3a** (0.20 g, 2.27 mmol), **4f** (0.28 g, 2.72 mmol), and Et_3N (0.27 g, 2.72 mmol), **1f** (0.14 g, 49%) as a white powder and **2f** (0.077 g, 26%) as a pale-yellow oil were afforded. Data for **1f**: R_f = 0.37 (hexane/EtOAc, 7:3); m.p. 63–64 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.86 (br. s, 3 H, CH_3C-4), 2.10 (br. s, 3 H, CH_3C-5), 3.82 (s, 3 H, MeO), 6.82–6.95 (m, 3 H, Ar-H), 7.31–7.39 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 8.7 (*C*H_3C-4), 9.9 (*C*H_3C-5), 55.3 (O*C*H_3), 112.6 (arom. *C*H), 113.9 (arom. *C*H), 117.8 (C-4), 119.0 (arom. *C*H), 130.0 (arom. *C*H), 132.2, 134.8, 154.4 (C-2), 160.2 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 1759, 1708, 1602, 1495, 1460, 1380, 1255, 1158, 1043, 1003 cm^{-1}. MS (70 eV): *m*/*z* (%) = 219 (10) [M]$^+$, 148 (10), 107 (30), 92 (14), 77 (100), 63 (42). HRMS (FAB): calcd. for $C_{12}H_{13}NO_3$ [M]$^+$ 219.0895; found 219.0895. Data for **2f**: R_f = 0.49 (hexane/EtOAc, 7:3). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.61 (d, *J* = 6.6 Hz, 3 H, CH_3C-5), 3.81 (s, 3 H, MeO), 4.08 (dd, *J* = 2.7, 2.1 Hz, 1 H, CH_2=), 4.23 (t, *J* = 2.7 Hz, 1 H, CH_2=), 5.20–5.29 (m, 1 H, 5-H), 6.88 (t, *J* = 2.4 Hz, 1 H, Ar-H), 6.92 (dd, *J* = 8.0, 2.1 Hz, 2 H, Ar-H), 7.38 (t, *J* = 8.1 Hz, 1 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 21.1 (*C*H_3C-5), 55.4 (O*C*H_3), 75.0 (C-5), 82.1 (*C*H_2=), 112.6 (arom. *C*H), 114.2 (arom. *C*H), 119.1 (arom. *C*H), 130.3 (arom. *C*H), 134.8 (arom. C), 147.4 (C-4), 155.2 (C-2), 160.4 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 1762, 1680, 1600, 1492, 1458, 1393, 1323, 1259, 1224, 1164, 1082, 1042, 1002, 866, 814, 783, 699 cm^{-1}. MS (70 eV): *m*/*z* (%) = 220 (85) [M + 1]$^+$, 176 (100), 161 (96), 134 (26), 104 (49), 78 (28), 63 (19). HRMS (EI): calcd. for $C_{12}H_{13}NO_3$ [M]$^+$ 219.0896; found 219.0896.

***N*-(Benzyl)-4,5-dimethyl-4-oxazolin-2-one (1g) and 1,3-Dibenzyl-4,5-dimethyl-1*H*-imidazol-2(3*H*)-one (11a):** Synthesized according to method A, with **3a** (0.88 g) and **4g** (1.33 g), **1g** (1.61 g, 79%) and **11a** (0.615 g, 21%) as white powders were afforded. Data for **1g**: R_f = 0.25 (hexane/EtOAc, 7:3); m.p. 95–96 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.82 (s, 3 H, CH_3C-4), 2.02 (s, 3 H, CH_3C-5), 4.73 (s, 2 H, PhCH_2N-3), 7.20–7.42 (m, 5 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 8.1 (*C*H_3C-4), 9.8 (*C*H_3C-5), 45.2 (Ph*C*H_2N-3), 117.2 (C-4), 127.0 (2 C, arom. *C*H), 127.7 (arom. *C*H), 128.7 (2 C, arom. *C*H), 131.5 (C-5), 136.4 (arom. C), 155.9 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1745, 1704, 1371, 755 cm^{-1}. MS (70 eV): *m*/*z* (%) = 203 (100) [M]$^+$, 112 (3), 91 (50), 65 (12). $C_{12}H_{13}NO$ (203.24): calcd. C 70.92, H 6.45, N 6.89; found C 71.16, H 6.68, N 6.97. Data for **11a**: R_f = 0.20 (hexane/EtOAc, 7:3); m.p. 122–123 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.85 (s, 6 H, 2 *C*H_3C), 4.87 (s, 4 H, 2 PhCH_2N), 7.20–7.38 (m, 10 H, 2 Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 8.6 (2 *C*H_3C), 44.6 (2 Ph*C*H_2N), 113.4 (C-4, C-5), 127.0 (4 C, arom. *C*H), 127.2 (2 C, arom. *C*H), 128.6 (4 C, arom. *C*H), 138.1 (2 C, arom. C), 153.8 (C-2) ppm. IR (film): $\tilde{\nu}$ = 2929, 1708, 1654 cm^{-1}. 1496, 1444, 1356, 1182, 1075, 700 cm^{-1}. MS (70 eV): *m*/*z* (%) = 292 (3) [M]$^+$, 92 (8), 91 (100), 65 (15). HRMS (EI): calcd. for $C_{19}H_{20}N_2O$ [M]$^+$ 292.1576; found 292.1584.

***N*-(2-Chloroethyl)-4,5-dimethyl-4-oxazolin-2-one (1h):**[9] Synthesized according to method A, with **3a** (0.88 g) and **4h** (1.05 g), **1e** (0.545 g, 31%) was afforded as a reddish oil. R_f = 0.50 (hexane/EtOAc, 7:3).

4-Methyl-*N*-phenyl-4-oxazolin-2-one (9a): Synthesized according to method A, with **3b** (0.74 g) and **4a** (1.19 g), **9a** (1.365 g, 78%) was afforded as colorless crystals (hexane/CH_2Cl_2, 1:6). Synthesized according to method B, with **3b** (0.10 g, 1.34 mmol) and **4a** (0.19 g, 1.62 mmol), **9a** (0.196 g, 83%) was afforded. Synthesized according to method C, with **3b** (0.10 g, 1.34 mmol), **4a** (0.19 g, 1.62 mmol), and Et_3N (0.13 g, 1.35 mmol), **9a** (0.158 g, 66%) was afforded. R_f = 0.31 (hexane/EtOAc, 7:3); m.p. 58–59 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.92 (d, *J* = 1.5 Hz, 3 H, CH_3C-4), 6.71 (q, *J* = 1.5 Hz, 1 H, 5-H), 7.30–7.38 (m, 2 H, Ph-H), 7.40–7.55 (m, 3 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 9.5 (*C*H_3C-4), 124.0 (C-5), 124.5 (C-4), 126.9 (2 C, arom. *C*H), 128.5 (arom. *C*H), 129.5 (2 C, arom. *C*H), 133.3 (arom. C), 155.0 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1754, 1665, 1597, 1502, 1396, 1385, 1278, 1152, 1076, 966, 762, 694 cm^{-1}. MS (70 eV): *m*/*z* (%) = 175 (46) [M$^+$], 118 (100), 103 (40), 91 (3), 77 (44), 52 (20). $C_{10}H_9NO_2$ (175.18): calcd. C 68.56, H 5.18, N 8.00; found C 68.42, H 4.95, N 8.25.

***N*-(4-Anisyl)-4-methyl-4-oxazolin-2-one (9b):** Synthesized according to method A, with **3b** (0.74 g) and **4d** (1.49 g), **9b** (1.645 g, 80%) was afforded as a white powder. R_f = 0.40 (hexane/EtOAc, 7:3); m.p. 103–104 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.88 (d, *J* = 1.7 Hz, 3 H, CH_3C-4), 3.84 (s, 3 H, MeO), 6.69 (q, *J* = 1.7 Hz, 1 H, 5-H), 6.96–7.02 (m, 2 H, Ar-H), 7.20–7.26 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 9.4 (*C*H_3C-4), 55.5 (OMe), 114.7 (2 C, arom. *C*H), 123.7 (C-5), 124.8 (C-4), 125.8 (arom. C), 128.3 (2 C, arom. *C*H), 155.4 (C-2), 159.5 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 1750, 1515, 1396, 1298, 1251, 1154, 1078, 968, 836 cm^{-1}. MS (70 eV): *m*/*z* (%) = 205 (10) [M]$^+$, 148 (12), 107 (15), 77 (100), 63 (42). $C_{11}H_{11}NO_3$ (205.21): calcd. C 64.38, H 5.40, N 6.83; found C 64.13, H 5.41, N 7.00.

4-Methyl-*N*-(3-tolyl)-4-oxazolin-2-one (9c): Synthesized according to method A, with **3b** (0.74 g) and **4i** (1.33 g), **9c** (1.47 g, 78%) was afforded as colorless crystals (hexane/CH_2Cl_2, 1:6). Synthesized according to method B, with **3b** (0.10 g, 1.34 mmol) and **4i** (0.22 g, 1.63 mmol), **9c** (0.216 g, 84%) was afforded. Synthesized according to method C, with **3b** (0.10 g, 1.34 mmol), **4i** (0.22 g, 1.63 mmol), and Et_3N (0.13 g, 1.35 mmol), **9c** (0.192 g, 75%) was afforded. R_f = 0.27 (hexane/EtOAc, 7:3); m.p. 56–57 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.90 (d, *J* = 1.4 Hz, 3 H, CH_3C-4), 2.39 (s, 3 H, CH_3Ar), 6.70 (q, *J* = 1.4 Hz, 1 H, 5-H), 7.08 (dm, *J* = 7.7 Hz, 1 H, Ar-H), 7.13 (br. s, 1 H, Ar-H), 7.21 (br. d, *J* = 7.7 Hz, 1 H, Ar-H), 7.36 (t, *J* = 7.7 Hz, 1 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 9.4 (*C*H_3C-4), 21.2 (*C*H_3Ar), 123.9 (C-5, arom. *C*H), 124.6 (C-4), 127.5 (arom. *C*H), 129.2 (arom. *C*H), 129.3 (arom. *C*H), 133.1 (arom. C), 139.6 (arom. C), 155.1 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1754, 1608, 1590, 1492, 1439, 1383, 1294, 1201, 1143, 1079, 791, 773, 700 cm^{-1}. MS (70 eV): *m*/*z* (%) = 189 (15) [M]$^+$, 132 (26), 91 (100), 65 (75), 63 (20), 51 (12), 39 (65). $C_{11}H_{11}NO_2$ (189.21): calcd. C 69.83, H 5.86, N 7.40; found C 69.78, H 5.76, N 7.31.

3,4,5-Triphenyl-4-oxazolin-2-one (10a): Synthesized according to method A, with **3c** (2.12 g) and **4a** (1.19 g), **10a** (2.53 g, 81%) was afforded as a white powder (EtOAc). R_f = 0.50 (hexane/EtOAc, 7:3); m.p. 219–220 °C (ref.[23] 211 °C).

***N*-(2-Chloroethyl)-4,5-diphenyl-4-oxazolin-2-one (10b) and 1,3-Bis(2-chloroethyl)-4,5-diphenyl-1*H*-imidazol-2(3*H*)-one (11b):** Synthesized according to method A, with **3c** (2.12 g) and **4h** (1.05 g), **10b** (1.49 g, 50%) as a white powder and **11b** (0.214 g, 6%) as colorless crystals were afforded. Data for **10b**: R_f = 0.50 (hexane/EtOAc, 7:3); m.p. 104–105 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.61 (t, *J* = 6.2, Hz, 2 H, $ClCH_2CH_2$N-3), 3.79 (t, *J* = 6.2, Hz, 2 H, $ClCH_2CH_2$N-3), 7.18–7.28 (m, 5 H, Ph-H), 7.42–7.48 (m, 2 H, Ph-H), 7.52–7.59 (m, 3 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 40.2 ($ClCH_2CH_2$N-3), 43.3 ($ClCH_2CH_2$N-3), 123.1 (C-4), 124.3 (2 C, arom. *C*H), 126.6 (arom. C), 127.5 (arom. C), 127.8 (arom. *C*H), 128.5 (2 C, arom. *C*H), 129.7 (2 C, arom. *C*H), 130.4 (arom. *C*H), 130.7 (2 C, arom. *C*H), 134.8 (C-5), 154.3 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1758, 1445, 1381, 1059, 758, 700 cm^{-1}. MS (70 eV): *m*/*z* (%) = 300 (1) [M]$^+$, 166 (5), 105 (50), 104 (96), 103 (100), 89 (15), 77 (98), 63 (65), 51 (52). $C_{17}H_{14}ClNO_2$ (299.75): calcd. C 68.12, H 4.71, N 4.67; found C 68.35, H 4.63, N 4.66. Data for **11b**: R_f = 0.20 (hexane/EtOAc, 7:3); m.p. 114–115 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.62 (t, *J* = 6.8, Hz, 4 H, $ClCH_2CH_2$N-3), 4.00 (t, *J* = 6.8, Hz, 4 H, $ClCH_2CH_2$N-3), 7.14–7.22 (m, 4 H, Ph-H), 7.25–7.36 (m, 6 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 40.9 (2 $ClCH_2CH_2$N-3), 43.1 (2 $ClCH_2CH_2$N-3), 121.2 (C-4, C-5), 128.3 (2 C, arom. C), 128.4 (2 C, arom. *C*H), 128.6 (4 C, arom. *C*H), 130.4 (4 C, arom. *C*H), 153.2 (C-2) ppm. IR (film): $\tilde{\nu}$ = 3055, 2961, 1687, 1500, 1446, 1397, 1362, 1262, 1017, 760, 705 cm^{-1}. MS (70 eV): *m*/*z* (%) = 364 (18) [M + 4]$^+$, 362 (64) [M + 2]$^+$, 360 (100) [M]$^+$, 298 (50), 249 (24), 236 (26), 206 (78), 179 (18), 105 (12), 77 (10). $C_{19}H_{18}Cl_2N_2O$ (361.27): calcd. C 63.17, H 5.02, N 7.75; found C 63.05, H 5.00, N 7.72.

(4*R,5*S**)-4-Hydroxy-4,5-dimethyl-*N*-phenyl-2-oxazolidinone (*anti*-5a) and (4*R**,5*R**)-4-Hydroxy-4,5-dimethyl-*N*-phenyl-2-oxazolidinone (*syn*-5a):** A mixture of **3a** (0.88 g, 0.01 mol) and **4a** (1.19 g, 0.01 mol) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and irradiated with MW (200 W) at 100 °C for 60 min. The mixture was diluted in CH_2Cl_2 (40 mL), poured into H_2O (100 mL), stirred for 30 min, and the precipitate filtered. The aqueous layer was washed with CH_2Cl_2 (2 × 40 mL), the combined organic layers were dried (Na_2SO_4), and the solvent removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per gram of crude, hexane/EtOAc, 9:1) to give a mixture of ***anti*-5a-/*syn*-5a** (85:15, 1.61 g, 78%), which after recrystallization (hexane/CH_2Cl_2, 1:1) afforded ***anti*-5a** (1.26 g, 61%) as colorless crystals. R_f = 0.55 (hexane/EtOAc, 1:1); m.p. 102–104 °C (ref.[9] 97–99 °C).

4-Hydroxy-4-methyl-*N*-phenyl-2-oxazolidinone (5b): Synthesized according to the method for the preparation of **5a**, with **3b** (0.74 g, 0.01 mmol) and **4a** (1.19 g, 0.01 mmol), **5b** (1.55 g, 80%) was afforded as colorless crystals. R_f = 0.45 (hexane/EtOAc, 7:3); m.p. 127–128 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.45 (s, 3 H, CH_3C-4), 4.26 (d, J = 9.5 Hz, 1 H, 5-H), 4.37 (d, J = 9.5 Hz, 1 H, 5-H), 6.15 (br. s, 1 H, OH), 7.25–7.50 (m, 5 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 24.3 (*C*H$_3$C-4), 76.0 (C-5), 87.7 (C-4), 127.0 (2 C, arom. *C*H), 127.2 (arom. *C*H), 128.9 (2 C, arom. *C*H), 134.5 (arom. C), 156.2 (C-2) ppm. IR (film): $\tilde{\nu}$ = 3326, 1735, 1502, 1427, 1242, 1153, 1077, 951, 759, 694 cm^{-1}. MS (70 eV): *m*/*z* (%) = 193 (18) [M]$^+$, 175 (28), 119 (100), 92 (20), 77 (19). $C_{10}H_{11}NO_3$ (193.20): calcd. C 62.17, H 5.74, N 7.25; found C 62.08, H 5.88, N 7.44.

3-Oxobutan-2-yl Phenylcarbamate (12): A mixture of **3a** (0.88 g, 0.01 mol) and **4a** (1.19 g, 0.01 mol) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and irradiated with MW (200 W) at 80 °C for 90 min. The mixture was dissolved in CH_2Cl_2 (25 mL) and the solvent removed under vacuum. The residue was crystallized from hexane/CH_2Cl_2 (6:1) to give **12** (1.75 g, 85%) as colorless crystals. R_f = 0.40 (hexane/EtOAc, 7:3); m.p. 66–67 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.44 (d, J = 7.2 Hz, Me-1), 2.22 (s, Me-4), 5.14 (q, J = 7.2, Hz, 1 H, 2-H), 6.85–6.90 (br. s, 1 H, NH), 7.00–7.10 (m, 1 H, Ar-H), 7.25–7.40 (m, 4 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 16.1 (*C*H$_3$-1), 25.7 (*C*H$_3$-4), 75.3 (*C*H-2), 118.7 (2 C, arom. *C*H), 123.7 (arom. *C*H), 129.1 (2 C, arom. *C*H), 137.3 (arom. C), 152.6 (HNCO), 206.4 (C-3) ppm. MS (70 eV): *m*/*z* (%) = 207 (11) [M]$^+$, 189 (23), 116 (60), 118 (100), 103 (6), 92 (22), 77 (70), 65 (24), 58 (33), 51 (30).

General Procedures for the Preparation of *N*-Substituted 5,5-Dimethyl-4-methylene-2-oxazolidinones 14a–14c. 5,5-Dimethyl-4-methylene-*N*-phenyl-2-oxazolidinone (14a)

Method A: A mixture of **3d** (1.02 g, 0.01 mol) and **4a** (1.19 g, 0.01 mol) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and irradiated with MW (300 W) at 140 °C for 3 h (see Table 3). The mixture was diluted with CH_2Cl_2 (40 mL), poured into H_2O (40 mL), and stirred for 1 h. The mixture was filtered and the aqueous layer was washed with CH_2Cl_2 (2 × 40 mL). The combined organic layers were dried (Na_2SO_4) and the solvent removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per gram of crude, hexane/EtOAc, 8:2) to give **14a** (1.37 g, 67%) as colorless crystals.

Method B: A mixture of **3d** (0.10 g, 0.98 mmol) and **4a** (0.152 g, 1.277 mmol) was placed in a threaded ACE glass pressure tube with a sealed Teflon screw cap under N_2. The mixture was stirred and heated at 130 °C for 24 h. The mixture was diluted with CH_2Cl_2 (10 mL), filtered, and the solvent removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per gram of crude, hexane/EtOAc, 8:2) to give **14a** (0.171 g, 86%) as colorless crystals. R_f = 0.78 (hexane/EtOAc, 7:3); m.p. 133–135 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.66 (s, 6 H, 2 CH_3C-5), 4.05 (d, J = 3.0 Hz, 1 H, CH_2=), 4.14 (d, J = 3.0 Hz, 1 H, CH_2=), 7.32–7.41 (m, 3 H, Ph-H), 7.45–7.52 (m, 2 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 28.1 (2 *C*H$_3$C-5), 81.1 (*C*H$_2$=), 82.5 (C-5), 127.0 (2 C, arom. *C*H), 128.3 (arom. *C*H), 129.5 (2 C, arom. *C*H), 134.0 (arom. C), 151.8 (C-4), 154.5 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1751, 1653, 1407, 1186, 1081, 836, 762, 702 cm^{-1}. MS (70 eV): *m*/*z* (%) = 203 (75) [M]$^+$, 158 (91), 144 (97), 118 (22), 104 (100), 91 (14), 77 (70), 51 (29). HRMS (EI): calcd. for $C_{12}H_{13}NO_2$ [M]$^+$ 203.0946; found 203.0948. $C_{12}H_{13}NO_2$ (203.24): calcd. C 70.92, H 6.45, N, 6.89; found C 71.18, H, 6.54, N, 6.94.

***N*-(4-Anisyl)-5,5-dimethyl-4-methylene-2-oxazolidinone (14b):** Synthesized according to method B, with **3d** (0.10 g, 0.98 mmol) and **4d** (0.175 g, 1.176 mmol), **14b** (0.21 g, 92%) was afforded as colorless crystals. R_f = 0.54 (hexane/EtOAc, 7:3); m.p. 101–102 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.62 (s, 6 H, 2 CH_3C-5), 3.83 (s, MeO), 4.02 (d, J = 2.9 Hz, 1 H, CH_2=), 4.06 (d, J = 2.9 Hz, 1 H, CH_2=), 6.95–7.01 (m, 2 H, Ar-H), 7.21–7.27 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 28.0 (2 *C*H$_3$C-5), 55.5 (*C*H$_3$O), 80.9 (*C*H$_2$=), 82.4 (C-5), 114.8 (2 C, arom. *C*H), 126.5 (arom. C), 128.4 (2 C, arom. *C*H), 154.5 (C-2), 159.3 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 1756, 1683, 1644, 1517, 1457, 1404, 1296, 1252, 1189, 825 cm^{-1}. MS (70 eV): *m*/*z* (%) = 233 (100) [M]$^+$, 189 (18), 174 (23), 158 (6), 133 (62), 103 (6). HRMS (EI): calcd. for $C_{13}H_{15}NO_3$ [M]$^+$ 233.1052; found 233.1049.

***N*-(2-Chloroethyl)-5,5-dimethyl-4-methylene-2-oxazolidinone (14c):** Synthesized according to method B, with **3d** (0.10 g, 0.98 mmol), **4h** (0.123 g, 1.166 mmol), and NEt_3 (0.0099 g, 0.098 mmol) and heating for 36 h, **14c** (0.099 g, 53%) was afforded as a white powder. R_f = 0.53 (hexane/EtOAc, 7:3); m.p. 60–61 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.53 (s, 6 H, 2 *C*H$_3$C-5), 3.66–3.72 (m, 2 H, ClCH$_2$C*H*$_2$N-3), 3.76–3.83 (m, 2 H, ClC*H*$_2$CH$_2$N-3), 4.07 (d, J = 3.3 Hz, 1 H, CH_2=), 4.17 (d, J = 3.3 Hz, 1 H, CH_2=) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 27.9 (2 *C*H$_3$C-5), 39.2 (ClCH$_2$*C*H$_2$N-3), 42.7 (Cl*C*H$_2$CH$_2$N-3), 79.8 (*C*H$_2$=), 82.6 (C-5), 150.4 (C-4), 155.3 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1750, 1736, 1685, 1637, 1440, 1409, 1372, 1335, 1297, 1267, 1151, 1080, 822 cm^{-1}. MS (70 eV): *m*/*z* (%) = 191 (24) [M + 2]$^+$, 189 (77) [M]$^+$, 174 (7), 154 (100), 110 (93), 96 (50), 82 (35), 68 (56), 63 (43), 56 (36). $C_8H_{12}ClNO_2$ (189.64): calcd. C 50.67, H 6.38, N 7.39; found C 50.42, H 6.56, N 7.18.

General Procedures for the Preparation of 5-Methyl-4-methylene-5-(3-oxobutyl)-*N*-phenyl-2-oxazolidinone (16a) and 5,7a-Dimethyl-3-phenyl-7,7a-dihydro-3*H*-benzoxazol-2-one (19a)

Method A: A mixture of **1a** (0.945 g, 0.005 mol) and **15a** (1.75 g, 0.025 mol) in dry xylene (10 mL) was heated at 160 °C under N_2 for 24 h in an ACE pressure tube sealed with a Teflon screw cap. The solvent was removed under vacuum and the residue was purified by column chromatography on silica gel (30 g, hexane/EtOAc, 9:1) to give **16a** (0.763 g, 59%) as colorless crystals (hexane/CH_2Cl_2, 1:1) and **19a** (0.164 g, 14%) as a colorless oil.

Method B: A mixture of **1a** (0.189 g, 0.001 mol) in dry THF (4 mL) and **15a** (0.35 g, 0.005 mol) in dry HMPA (0.5 mL) was placed in an ACE pressure tube sealed with a Teflon screw cap under N_2 and in darkness. At 20 °C, $AlCl_3$ (0.147 g, 0.001 mol) was added and the mixture was heated at 70 °C for 72 h. The residue was poured into H_2O (50 mL) and extracted with CH_2Cl_2 (3 × 20 mL). The organic layer was dried (Na_2SO_4), the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (30 g, hexane/EtOAc, 9:1) to give **16a** (0.109 g, 42%) as colorless crystals (hexane/CH_2Cl_2, 1:1) and **19a** (0.087 g, 36%) as a colorless oil.

Data for **16a**: R_f = 0.50 (hexane/EtOAc, 7:3); m.p. 107–108 °C (ref.[9] 94–96 °C). Data for **19a**: R_f = 0.37 (hexane/EtOAc, 9:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.49 (s, 3 H, CH_3C-7a), 1.76 (dd, J = 1.8, 1.5 Hz, 3 H, CH_3C-5), 2.40 (ddd, J = 16.2, 6.3, 0.6 Hz, 1 H, 7-H), 2.56 (t, J = 16.2, 2.7 Hz, 1 H, 7-H), 5.04 (s, 1 H, 4-H), 5.33–5.39 (m, 1 H, 6-H), 7.30–7.38 (m, 1 H, Ph-H), 7.40–7.50 (m, 4 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 21.6 (*C*H$_3$), 21.9 (*C*H$_3$), 34.3 (C-7), 81.3 (C-7a), 96.7 (C-4), 113.8 (C-6), 125.4 (2 C,

arom. *C*H), 127.7 (arom. *C*H), 129.4 (2 C, arom. *C*H), 132.2 (C-5), 134.1 (arom. C), 142.3 (C-3a), 155.4 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1754, 1675, 1598, 1501, 1406, 1334, 1196, 1072, 1019, 761, 697 cm^{-1}. MS (70 eV): *m*/*z* (%) = 241 (89) $[M]^+$, 196 (100). 182 (78), 167 (29), 105 (30), 77 (68), 51 (26). $C_{15}H_{15}NO_2$ (241.29): calcd. C 74.67, H 6.27, N 5.81; found C 74.96, H 6.53, N 5.59.

General Procedures for the Preparation of 2,5-Dimethyl-*N*-phenylaniline (20a)

Method A: A mixture of **1a** (0.189 g, 0.001 mol), **15a** (0.35 g, 0.005 mol) in dry MeCN (10 mL), and $ZnCl_2$ (0.680 g, 0.005 mol) was heated at 160 °C under N_2 and in darkness for 72 h in an ACE pressure tube sealed with a Teflon screw cap. The residue was extracted with EtOAc (3 × 15 mL) and with CH_2Cl_2 (3 × 15 mL). The solvent was removed under vacuum and the residue was purified by column chromatography on silica gel (30 g, hexane/EtOAc, 9:1) to give **20a** (0.07 g, 35%) as a pale-pink oil, which quickly darkened.

Method B: A mixture of **16a** (0.259 g, 0.001 mol) in dry acetonitrile (5 mL) and $ZnCl_2$ (0.680 g, 0.005 mol) was placed in an ACE pressure tube sealed with a Teflon screw cap under N_2 and in darkness, and heated at 160 °C for 24 h. The residue was suspended in EtOAc (20 mL) and washed with H_2O (20 mL). The aqueous layer was washed with EtOAc (2 × 20 mL) and the combined organic layers were dried (Na_2SO_4). The solvent was removed under vacuum and the residue was purified by column chromatography on silica gel (30 g, hexane/EtOAc, 9:1) to give **20a** (0.095 g, 49%) as a pale-pink oil that quickly darkened. R_f = 0.80 (hexane/EtOAc, 8:2). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.22 (s, 3 H, CH_3Ar), 2.27 (s, 3 H, CH_3Ar), 6.75 (br. d, *J* = 7.4 Hz, 1 H, Ar-H), 6.86–6.99 (m, 3 H, Ph-H), 7.07 (br. s, 1 H, Ar-H), 7.09 (d, *J* = 7.4 Hz, 1 H, Ar-H), 7.21–7.30 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 17.5 (*C*H_3Ar), 21.1 (*C*H_3Ar), 117.4 (2 C, arom. *C*H), 119.3 (arom. *C*H), 120.3 (arom. *C*H), 122.7 (arom. *C*H), 129.3 (2 C, arom. *C*H), 130.7 (arom. *C*H), 131.5 (arom. C), 136.4 (arom. C), 144.0 (arom. C), 149.5 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 3381, 2924, 1598, 1497, 1461, 1310, 802, 746 cm^{-1}. MS (70 eV): *m*/*z* (%) = 197 (76) $[M]^+$, 120 (34), 91 (42), 77 (100), 51 (90), 39 (53). HRMS (FAB): calcd. for $C_{14}H_{15}N$ $[M]^+$ 197.1204; found 197.1203.

2-Methyl-*N*-phenylaniline (20b): Synthesized according to method A for the preparation of **20a**, a mixture of **1a** (0.378 g, 0.002 mol) and **15b** (0.56 g, 0.01 mol) in dry xylene (10 mL) was heated at 160 °C for 96 h to afford **20b** (0.32 g, 87%) as a colorless oil that quickly darkened. R_f = 0.87 (hexane/EtOAc, 7:3). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.28 (s, 3 H, CH_3Ar), 5.40 (br. s, 1 H, NH), 6.90–7.05 (m, 4 H, Ar-H), 7.10–7.30 (m, 5 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 17.9 (*C*H_3Ar), 117.4 (2 C, arom. *C*H), 118.7 (arom. *C*H), 120.4 (arom. *C*H), 121.9 (arom. *C*H), 126.7 (arom. *C*H), 128.2 (arom. C), 129.3 (2 C, arom. *C*H), 130.9 (arom. *C*H), 141.2 (arom. C), 143.9 (arom. C) ppm. IR (film): $\tilde{\nu}$ = 3380, 2923, 1593, 1498, 1308, 746 cm^{-1}. MS (70 eV): *m*/*z* (%) = 184 (35) $[M + 1]^+$, 183 (100), 106 (45), 90 (52), 77 (75), 51 (50). HRMS (FAB): calcd. for $C_{13}H_{13}N$ $[M]^+$ 183.1048; found 183.1043.

General Procedures for the Preparation of 5-Methyl-4-methylene-5-(3-oxobutyl)-*N*-phenyl-2-oxazolidinone (16a) and (3a*R,7a*S**)-3a,5,7a-Trimethyl-3-phenyl-3,3a,7,7a-tetrahydro-2*H*-pyrano[2,3-*d*]-oxazol-2-one (21a)**

Method A: A mixture of **1a** (1.90 g, 0.01 mol) and **15a** (3.50 g, 0.05 mol) was irradiated with MW (300 W) and heated at 140 °C in an ACE pressure tube sealed with a Teflon screw cap under N_2 for 6 h. The residue was extracted with EtOAc (3 × 20 mL), the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (40 g, hexane/EtOAc, 9:1) to give **16a** (2.0 g, 77%) as colorless crystals (hexane/CH_2Cl_2, 1:1) and **21a** (0.41 g, 16%) as a white solid.

Method B: Synthesized according to method A, a mixture of **1a** (0.19 g, 0.001 mol) and **15a** (0.35 g, 0.005 mol) was irradiated with MW (400 W) and heated at 160 °C for 6 h to give **21a** (0.088 g, 34%) as a white solid.

Method C: Synthesized according to method B, a mixture of **16a** (0.10 g, 0.39 mmol) and **15a** (0.135 g, 1.9 mmol) was irradiated with MW (400 W) and heated at 160 °C for 4 h to give **21a** (0.09 g, 34%) as a white solid.

Data for **16a**: R_f = 0.50 (hexane/EtOAc, 7:3); m.p. 95–96 °C (ref.[9] 94–96 °C). Data for **21a**: R_f = 0.30 (hexane/EtOAc, 7:3); m.p. 115–116 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.49 (s, 3 H, CH_3C-7a), 1.57 (s, 3 H, CH_3C-3a), 1.85 (br. s, 3 H, CH_3C-5), 2.23–2.34 (dm, *J* = 16.5 Hz, 1 H, 7-H), 2.47 (dd, *J* = 16.5, 6.6 Hz, 1 H, 7-H), 4.83–4.89 (m, 1 H, 6-H), 7.30–7.38 (m, 1 H, Ar-H), 7.40–7.43 (m, 4 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 19.5 (*C*H_3), 20.9 (*C*H_3), 24.1 (*C*H_3C-5), 30.1 (C-7), 84.0 (C-7a), 94.4 (C-3a), 98.0 (C-6), 127.1 (2 C, arom. *C*H), 127.5 (arom. *C*H), 129.0 (2 C, arom. *C*H), 134.8 (arom. C), 150.9 (C-5), 155.5 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1764, 1713, 1675, 1499, 1395, 1324, 1239, 1170, 1070, 981, 765, 698 cm^{-1}. MS (70 eV): *m*/*z* (%) = 260 (13) $[M + 1]^+$, 259 (6) $[M]^+$, 241 (8), 197 (16), 189 (100), 144 (12), 118 (55), 77 (15). HRMS (EI): calcd. for $C_{15}H_{17}NO_3$ $[M]^+$ 259.1208; found 259.1195.

General Procedures for the Preparation of (3a*R,7a*S**)-3a,7a-Dimethyl-3-phenyl-3,3a,7,7a-tetrahydro-2*H*-pyrano[2,3-*d*]oxazol-2-one (21b)**

Method A: A mixture of **1a** (0.378 g, 0.002 mol) and **15b** (0.623 g, 0.011 mol) in dry xylene (4 mL) was heated at 80 °C under N_2 and in darkness in an ACE pressure tube sealed with a Teflon screw cap for 5 d. The residue was extracted with EtOAc (3 × 15 mL) and CH_2Cl_2 (3 × 20 mL). The combined organic layers were filtered, the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (40 g, hexane/EtOAc, 9:1) to give **21b** (0.402 g, 81%) as colorless crystals (hexane/CH_2Cl_2, 6:1).

Method B: A mixture of **1a** (0.378 g, 0.002 mol) and **15b** (1.12 g, 0.02 mol) was irradiated with MW (200 W) and heated at 100 °C under N_2 in an ACE pressure tube sealed with a Teflon screw cap for 6 h. The residue was extracted with EtOAc (3 × 15 mL) and CH_2Cl_2 (3 × 15 mL). The combined organic layers were filtered, the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (40 g, hexane/EtOAc, 9:1) to give **21b** (0.378 g, 77%) as colorless crystals (hexane/CH_2Cl_2, 6:1). R_f = 0.37 (hexane/EtOAc, 7:3); m.p. 127–128 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.48 (s, 3 H, CH_3C-7a), 1.60 (s, 3 H, CH_3C-3a), 2.32 (dt, *J* = 16.8, 2.8 Hz, 1 H, 7-H), 2.53 (dd, *J* = 16.8, 6.6 Hz, 1 H, 7-H), 5.12–5.19 (m, 1 H, 6-H), 6.51 (dd, *J* = 5.5, 3.0 Hz, 1 H, 5-H), 7.35–7.45 (m, 5 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 20.9 (*C*H_3C-7a), 24.5 (*C*H_3C-3a), 29.5 (C-7), 84.3 (C-7a), 94.5 (C-3a), 103.9 (C-6), 127.6 (2 C, arom. *C*H), 127.9 (arom. *C*H), 129.1 (2 C, arom. *C*H), 134.4 (arom. C), 143.0 (C-5), 155.5 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1760, 1654, 1499, 1386, 1214, 1140, 1052, 758, 698 cm^{-1}. MS (70 eV): *m*/*z* (%) = 245 (3) $[M]^+$, 189 (84), 118 (100), 77 (39). $C_{14}H_{15}NO_3$ (245.27): calcd. C 68.56, H 6.16, N 5.71; found C 68.39, H 5.97, N 5.93.

(3a*R,7a*S**)-3a-Methyl-3-phenyl-3,3a,7,7a-tetrahydro-2*H*-pyrano-[2,3-*d*]oxazol-2-one (21c):** Synthesized according to method A for the preparation of **21b**, a mixture of **9a** (0.351 g, 0.002 mol) and **15b** (0.224 g, 0.004 mol) in dry xylene (4 mL) was heated at 100 °C

for 24 h to give **21c** (0.34 g, 74%) as a white powder. R_f = 0.35 (hexane/EtOAc, 7:3); m.p. 95–96 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.55 (s, 3 H, CH_3C-3a), 2.45 (ddt, J = 17.5, 4.2, 2.6 Hz, 1 H, 7-H), 2.58 (ddd, J = 17.5, 6.2, 1.9 Hz, 1 H, 7-H), 4.77–4.82 (m, 1 H, 7a-H), 5.12–5.19 (m, 1 H, 6-H), 6.51 (dd, J = 5.5, 3.0 Hz, 1 H, 5-H), 7.30–7.45 (m, 5 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 21.9 (C-7), 23.4 (*C*H$_3$C-3a), 78.4 (C-7a), 90.6 (C-3a), 101.4 (C-6), 127.3 (2 C, arom. *C*H), 127.8 (arom. *C*H), 129.1 (2 C, arom. *C*H), 134.4 (arom. C), 143.0 (C-5), 155.8 (C-2) ppm. IR (film): $\tilde{\nu}$ = 2924, 1753, 1652, 1597, 1497, 1378, 1198, 1120, 1056, 975, 861, 759, 695 cm^{-1}. MS (70 eV): *m*/*z* (%) = 232 (7) [M + 1]$^+$, 231 (3) [M]$^+$, 188 (4), 176 (6), 91 (6), 77 (100), 51 (52). HRMS (EI): calcd. for $C_{13}H_{13}NO_3$ [M]$^+$ 231.0895; found 231.0889.

General Procedures for the Preparation of 7a-Methyl-3-phenyl-7,7a-dihydro-3*H*-benzoxazol-2-one (19b) and 3-(7a-Methyl-2-oxo-3-phenyl-2,3,7,7a-tetrahydrobenzo[*d*]oxazol-6-yl)propanal (24)

Method A: A mixture of **1a** (0.38 g, 0.002 mol), **15b** (0.342 g, 0.006 mol) in dry xylene (4 mL), and MeI (0.568 g, 0.004 mol) was heated at 160 °C under N_2 and in darkness in an ACE pressure tube sealed with a Teflon screw cap for 24 h. The mixture was extracted with EtOAc (3 × 20 mL) and CH_2Cl_2 (3 × 20 mL). The combined organic layers were filtered, the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (30 g per 1 g of mixture, hexane/EtOAc, 9:1) to give 0.42 g (93%) of **19b** as colorless crystals.

Method B: Synthesized according to method A, a mixture of **1a** (0.38 g, 0.002 mol), **15b** (0.56 g, 0.01 mol) in dry xylene (4 mL), and MeI (0.568 g, 0.004 mol), was heated at 160 °C for 24 h to give **19b** (0.095 g, 21%) as a white powder and **24** (0.326 g, 58%) as a colorless oil.

Method C: Compound **1a** (0.30 g, 1.59 mmol) in dry CH_2Cl_2 (4 mL) was added to a mixture of **15b** (0.356 g, 6.36 mmol) and iodine (0.08 g, 0.319 mmol) in dry CH_2Cl_2 (3.6 mL) and stirred at 0 °C under N_2 for 2.5 h. The mixture was diluted with CH_2Cl_2 (20 mL), poured into a 10% aqueous solution of sodium thiosulfate (40 mL), and stirred until the red color had disappeared. The aqueous layer was washed with CH_2Cl_2 (2 × 20 mL), the combined organic layers were dried (Na_2SO_4), and the solvent was removed under vacuum. The residue was purified by column chromatography on silica gel (30 g per 1 g of mixture, hexane/EtOAc, 9:1) to afford **19b** (0.112 g, 31%) as a white powder.

Data for **19b**: R_f = 0.65 (hexane/EtOAc, 7:3); m.p. 103–105 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.51 (s, 3 H, CH_3C-7a), 2.52 (dd, J = 16.7, 6.2 Hz, 1 H, 7-H), 2.70 (dm, J = 16.7 Hz, 1 H, 7-H), 5.17 (d, J = 5.5 Hz, 1 H, 4-H), 5.64–5.72 (m, 1 H, 6-H), 5.92–6.01 (m, 1 H, 5-H), 7.30–7.54 (m, 5 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 21.8 (*C*H$_3$), 34.0 (C-7), 80.9 (C-7a), 93.2 (C-4), 119.4 (C-6), 124.1 (C-5), 125.3 (2 C, arom. *C*H), 127.6 (arom. *C*H), 129.4 (2 C, arom. *C*H), 134.0 (arom. C), 142.0 (C-3a), 155.1 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1770, 1674, 1499, 1406, 1334, 1201, 1074, 1016 cm^{-1}. MS (70 eV): *m*/*z* (%) = 227 (5) [M]$^+$, 182 (25), 106 (19), 91 (38), 79 (64), 77 (100), 51 (76). HRMS (FAB): calcd. for $C_{14}H_{13}NO_2$ [M]$^+$ 227.0946; found 227.0945.

Data for **24**: R_f = 0.27 (hexane/EtOAc, 7:3). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.48 (s, 3 H, CH_3C-7a), 2.33 (d, J = 16.0 Hz, 1 H, 7-H), 2.44–2.54 (m, 2 H, OHCCH$_2$CH_2-6), 2.58–2.66 (m, 2 H, OHCCH_2CH$_2$-6), 2.74 (dm, J = 16.0 Hz, 1 H, 7-H), 5.14 (d, J = 5.5 Hz, 1 H, 4-H), 5.68–5.74 (m, 1 H, 5-H), 7.30–7.52 (m, 5 H, Ar-H), 9.79 (t, J = 1.5 Hz, 1 H, CHO) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 22.0 (*C*H$_3$), 29.0 (OHCCH$_2$*C*H$_2$-6), 38.2 (C-7), 41.5 (OHC*C*H$_2$CH$_2$-6), 81.1 (C-7a), 93.2 (C-4), 119.1 (C-5), 125.2 (2 C, arom. *C*H), 127.6 (arom. *C*H), 129.4 (2 C, arom. *C*H), 131.1 (C-6), 134.1 (arom. C), 140.6 (C-3a), 155.2 (C-2), 201.3 (CHO) ppm. IR (film): $\tilde{\nu}$ = 1770, 1700, 1676, 1600, 1499, 1403, 1335, 1217, 1014, 762, 696 cm^{-1}. MS (70 eV): *m*/*z* (%) = 283 (5) [M]$^+$, 239 (20), 196 (100), 183 (15), 167 (5), 91 (5), 77 (5). HRMS (FAB): calcd. for $C_{17}H_{18}NO_3$ [M + 1]$^+$ 284.1287; found 284.1295.

4-Methyl-5-(3-oxobutyl)-*N*-phenyl-4-oxazolidin-2-one (16c): Synthesized according to method A for the preparation of **16a** and **19a**, a mixture of **9a** (0.351 g, 0.002 mol) and **15a** (0.28 g, 0.004 mol) gave **16c** (0.426 g, 87%) as colorless crystals (hexane/CH_2Cl_2, 6:1). R_f = 0.20 (hexane/EtOAc, 6:4); m.p. 85–86 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.90 (s, 3 H, CH_3C-4), 2.19 (s, 3 H, CH_3CO), 2.67–2.75 (m, 2 H, AcCH$_2$CH_2C-5), 2.77–2.84 (m, 2 H, AcCH_2CH$_2$C-5), 7.26–7.31 (m, 2 H, Ar-H), 7.35–7.41 (m, 1 H, Ar-H), 7.42–7.50 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 8.7 (*C*H$_3$C-4), 18.4 (AcCH$_2$*C*H$_2$C-5), 29.9 (*C*H$_3$CO), 40.3 (Ac*C*H$_2$CH$_2$C-5), 118.6 (C-4), 126.8 (2 C, arom. *C*H), 128.2 (arom. *C*H), 129.3 (2 C, arom. *C*H), 133.7 (C-5), 134.4 (arom. C), 154.5 (C-2), 206.7 (CO) ppm. IR (film): $\tilde{\nu}$ = 1754, 1708, 1597, 1498, 1427, 1376, 1246, 1166, 979, 762, 700 cm^{-1}. MS (70 eV): *m*/*z* (%) = 246 (8) [M + 1]$^+$, 245 (6) [M]$^+$, 188 (22), 144 (22), 128 (12), 118 (33), 77 (100), 51 (48). HRMS (EI): calcd. for $C_{14}H_{15}NO_3$ [M]$^+$ 245.1052; found 245.1060.

3a,5,7a-Trimethyl-3-phenyl-3a,6,7,7a-tetrahydro-3*H*-benzoxazol-2-one (26): A mixture of **1a** (0.378 g, 0.002 mol) and **25** (1.49 g, 0.01 mol) in dry xylene (4 mL) was heated at 160 °C under N_2 and in darkness in an ACE pressure tube sealed with a Teflon screw cap for 24 h. The mixture was extracted with EtOAc (3 × 15 mL) and with CH_2Cl_2 (3 × 15 mL). The combined organic layers were filtered, the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (30 g per 1 g of mixture, hexane/EtOAc, 9:1), to afford **26** (0.27 g, 53%) as colorless crystals (hexane/CH_2Cl_2, 6:1). R_f = 0.32 (hexane/EtOAc, 8:2); m.p. 121–122 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.20 (s, CH_3C-3a), 1.49 (s, 3 H, CH_3C-7a), 1.73 (br. s, 3 H, CH_3C-5), 1.75–1.86 (m, 1 H, 7-H), 1.92 (dm, J = 17.3 Hz, 1 H, 6-H), 2.17 (ddd, J = 13.8, 5.1, 4.4 Hz, 1 H, 7-H), 2.25–2.38 (m, 1 H, 6-H), 5.09 (br. s, 1 H, 4-H), 7.20–7.26 (m, 2 H, Ar-H), 7.30–7.44 (m, 3 H, Ar-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 21.4 (*C*H$_3$C-3a), 21.7 (*C*H$_3$C-7a), 23.4 (*C*H$_3$C-5), 26.3 (C-6), 30.9 (C-7), 63.7 (C-3a), 81.6 (C-7a), 122.6 (C-4), 127.7 (arom. *C*H), 128.9 (2 C, arom. *C*H), 129.1 (2 C, arom. *C*H), 135.4 (C-5), 136.9 (arom. C), 156.6 (C-2) ppm. IR (film): $\tilde{\nu}$ = 1748, 1597, 1498, 1446, 1376, 1226, 1153, 1096, 1050, 969, 764 cm^{-1}. MS (70 eV): *m*/*z* (%) = 258 (26) [M + 1]$^+$, 257 (3) [M]$^+$, 121 (10), 118 (10), 105 (45), 95 (45), 93 (86), 91 (42), 81 (64), 77 (100), 67 (39), 65 (25), 51 (32). HRMS (EI): calcd. for $C_{16}H_{19}NO_2$ [M]$^+$ 257.1416; found 257.1415.

5-Methyl-5-(3-methylbut-2-enyl)-4-methylene-3-phenyloxazolidin-2-one (28): A mixture of **1a** (0.150 g, 0.795 mmol) and **25** (0.354 g, 2.378 mmol) in dry xylene (1.5 mL) was heated at 100 °C under N_2 and in darkness in an ACE pressure tube sealed with a Teflon screw cap for 36 h. The mixture was extracted with EtOAc (3 × 15 mL) and CH_2Cl_2 (3 × 15 mL), the solvent was removed under vacuum, and the residue was purified by column chromatography on silica gel (30 g per 1 g of mixture, hexane/EtOAc, 98:2) to afford **28** (0.037 g, 18%) as a pale-yellow oil. R_f = 0.68 (hexane/EtOAc, 7:3). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.62 (s, 3 H, CH_3C-5), 1.68 (br. s, 3 H, CH_3CH=), 1.76 (br. s, 3 H, CH_3CH=), 2.44 (dd, J = 14.5, 7.8 Hz, 1 H, CH_2CH=), 2.62 (dd, J = 14.5, 7.0 Hz, 1 H, CH_2CH=), 4.03 (d, J = 2.7 Hz, 1 H, H_2C=), 4.13 (d, J = 2.7 Hz, 1 H, H_2C=), 5.19–5.28 (m, 1 H, *H*C=), 7.25–7.53 (m, 5 H, Ph-H) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 18.2 (*C*H$_3$C-5), 26.0 (*C*H$_3$CH=),

Table 4. Crystal data and structure refinement for **10b**, **14b**, **19b**, **21b**, and **26**.

Structure	**10b**	**14b**	**19b**	**21b**	**26**
Empirical formula	$C_{17}H_{14}ClNO_2$	$C_{13}H_{15}NO_3$	$C_{14}H_{13}NO_2$	$C_{14}H_{15}NO_3$	$C_{16}H_{19}NO_2$
Molecular weight	299.74	233.26	227.25	245.27	257.32
Temperature [K]	294(2)	294(2)	294(2)	294(2)	294(2)
Crystal size [mm^3]	$0.44\times0.30\times0.28$	$0.36\times0.22\times0.16$	$0.35\times0.30\times0.25$	$0.80\times0.76\times0.48$	$0.40\times0.38\times0.26$
Crystal system	monoclinic	monoclinic	triclinic	orthorhombic	orthorhombic
Space group	*Cc*	P_121/c_1	$P\bar{1}$	*Pbca*	*Pbcn*
a [Å]	15.648(3)	14.3453(3)	7.9291(3)	11.8679(6)	30.369(2)
b [Å]	11.2784(6)	6.25270(10)	9.1092(6)	14.1438 (24)	11.8433(8)
c [Å]	8.4257(5)	14.6418(3)	9.6086(5)	15.1326(11)	7.8962(4)
α [°]	90	90	109.688(5)	90	90
β [°]	100.909(5)	110.130(2)	110.085(4)	90	90
γ [°]	90	90	100.239(4)	90	90
Volume [Å^3]	1460.1(3)	1233.10(4)	578.92 (7)	2540.1(5)	2840.0(3)
Z	4	4	2	8	8
Density [mg/m^3]	1.364	1.256	1.304	1.283	1.204
Absorption coefficient [mm^{-1}]	2.345	0.090	0.088	0.741	0.629
θ range [°]	4.86–56.88	2.83–32.56	2.50–32.51	5.68–57.00	4.01–57.04
Reflections collected	1245	11607	8804	2247	2597
Independent reflections	1109	4067	3792	1707	1928
Observed reflections	1077	2660	2669	1565	1398
R_1	0.0626	0.0456	0.0418	0.0420	0.0918
wR_2	0.1509	0.1195	0.1245	0.1044	0.2023
Goodness-of-fit on F^2	1.075	1.048	1.148	1.047	1.034

26.1 (*C*H$_3$CH=), 39.7 (*C*H$_2$CH=), 81.4 (H$_2$*C*=), 84.9 (C-5), 116.3 (*H*C=), 127.1 (2 C, arom. *C*H), 128.3 (arom. *C*H), 129.5 (2 C, arom. *C*H), 134.2 (Me$_2$*C*=), 137.2 (arom. C), 150.5 (C-4), 156.0 (C-2) ppm. IR (film): $\tilde{\nu}$ = 2923, 1772, 1676, 1502, 1454, 1397, 1320, 1292, 1228, 1147, 1062, 982 cm^{-1}. HRMS (FAB): calcd. for $C_{16}H_{19}NO_2$ [M]$^+$ 257.1416; found 257.1422.

Single-Crystal X-ray Crystallography: Single crystals of **10b** and **14b** were obtained by recrystallization from CH_2Cl_2/hexane (1:1), compound **21b** from CH_2Cl_2/hexane (7:3), and compounds **19b** and **26** from CH_2Cl_2/hexane (1:6) as colorless crystals. These were mounted on glass fibers. Crystallographic measurements were performed using Mo-K_α radiation (graphite crystal monochromator, λ = 71073 Å) and at room temperature. Three standard reflections were monitored periodically; they showed no change during data collection. Unit cell parameters were obtained from least-squares refinement of 26 reflections in the range $2 < 2\theta < 20°$. Intensities were corrected for Lorentzian and polarization effects. No absorption correction was applied. Anisotropic temperature factors were introduced for all non-hydrogen atoms. Hydrogen atoms were placed in idealized positions and their atomic coordinates refined. Unit weights were used in the refinement (Table 4). Structures were solved by using the SHELXTL,[24] SHELX97,[25] or SIR92[26] programs as implemented in the WinGX suite[27] and refined by using SHELXTL or SHELX97 within WinGX on a personal computer. In all cases ORTEP and packing diagrams were produced with the PLATON software package.[28]

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