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A PROOF-OF-CONCEPT SYNTHESIS OF 4-OXAZOLIDINONE CYCLOHEXADIENONES

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Abstract

Herein, we report a proof-of-concept approach to 4-oxazolidinone cyclohexadienones through a sequence of amide coupling, deacetylation, and oxidative dearomatization/intramolecular O-cyclization. O-acetyl mandelic acid was coupled with a series of N-alkylated aminophenol derivatives using N-(3-dimethylaminopropyl)-N'-ethylcarbodiimide (EDC) to afford amide substrates containing both a phenolic unit and a masked pendant oxygen nucleophile. Subsequent K_2CO_3-mediated deacetylation provided the corresponding secondary alcohols. Treatment of representative substrates 4a and 4d with (diacetoxyiodo)benzene (PIDA) in 2,2,2-trifluoroethanol at room temperature afforded the corresponding cyclized products 5a and 5d. Product formation is consistent with PIDA-mediated oxidative dearomatization of the phenolic ring followed by intramolecular O-nucleophilic ipso cyclization of the pendant hydroxy group to construct the five-membered 4-oxazolidinone ring. These results demonstrate the feasibility of using a pendant oxygen nucleophile to trap an oxidatively activated phenolic intermediate and provide a foundation for further investigation of the substrate scope, and synthetic utility of this transformation.

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Introduction

Oxazolidinones are an important class of nitrogen- and oxygen-containing heterocycles that have attracted considerable attention in synthetic and medicinal chemistry.[1–7] Although numerous approaches to oxazolidinone derivatives have been reported[8–16], methods that combine formation of the oxazolidinone ring with simultaneous generation of a highly functionalized, nonaromatic framework remain comparatively less explored. In this context, 4-oxazolidinone cyclohexadienones represent attractive synthetic targets because they combine an N,O-containing heterocycle with a reactive cyclohexadienone framework containing multiple sites for subsequent functionalization. Development of concise approaches to these structurally enriched scaffolds from readily accessible starting materials would therefore expand the synthetic utility of oxazolidinone chemistry.

Oxidative dearomatization of phenols provides a powerful strategy for converting relatively simple aromatic substrates into highly functionalized, three-dimensional products.[17–21] Oxidation of a phenolic substrate generates an electrophilic dearomatized intermediate that can undergo intra- or intermolecular nucleophilic trapping, enabling rapid formation of new carbon–heteroatom or carbon–carbon bonds.[22] In particular, incorporation of a pendant nucleophile into the phenolic substrate can facilitate intramolecular trapping of the oxidatively activated intermediate, providing an efficient strategy for heterocycle construction. Hypervalent iodine reagents, including (diacetoxyiodo)benzene (PIDA), are particularly useful for these transformations because they promote oxidative dearomatization under relatively mild, transition-metal-free conditions.[17,23]

Despite these advances, intramolecular oxidative dearomatization involving a pendant oxygen nucleophile presents considerations that differ from analogous nitrogen-based cyclizations. The oxygen nucleophile must compete effectively with solvent or other external nucleophiles for trapping of the reactive dearomatized intermediate, while its nucleophilicity, tether geometry, and the substitution pattern of the phenolic ring may influence the efficiency and selectivity of cyclization. Consequently, whether a pendant secondary alcohol derived from mandelic acid could efficiently participate in intramolecular ipso cyclization under oxidative dearomatization conditions was not evident at the outset of this study.

Recently, our group developed a one-pot, three-component strategy for the synthesis of highly functionalized imidazolidinone cyclohexadienones containing multiple contiguous stereogenic centers.[24] This transformation employs Boc-protected amino acids and aminophenol derivatives and is proposed to proceed through oxidative dearomatization followed by intramolecular trapping by a pendant nitrogen nucleophile. These results demonstrated that nucleophile-directed oxidative dearomatization can provide rapid access to structurally complex nitrogen-containing heterocycles. Building on this work, we sought to determine whether replacement of the pendant nitrogen nucleophile with an oxygen-based nucleophile could enable construction of the corresponding 4-oxazolidinone cyclohexadienone framework. Our strategy begins with coupling of O-acetyl mandelic acid with N-alkylated aminophenol derivatives to generate amides containing both the phenolic unit required for oxidative activation and a protected pendant oxygen nucleophile. Subsequent deacetylation reveals the corresponding secondary alcohol, positioning the oxygen nucleophile for intramolecular cyclization.

We report herein a proof-of-concept study demonstrating this strategy using representative aminophenol-derived substrates. Treatment of the resulting hydroxy-containing phenols with PIDA in 2,2,2-trifluoroethanol (TFE) afforded products consistent with oxidative dearomatization followed by intramolecular O-nucleophilic ipso cyclization to generate the targeted 4-oxazolidinone cyclohexadienone framework. These initial results establish the feasibility of pendant alcohol trapping in this oxidative dearomatization manifold and provide a foundation for further investigation of substrate scope, stereochemical outcome, and synthetic utility.

Materials and Methods

Racemic O-Acetyl mandelic acid, N-(3-dimethylaminopropyl)-N′-ethylcarbodiimide **(EDC)**, and (diacetoxyiodo)benzene (PIDA) were purchased from Oakwood Chemical and used as received unless otherwise stated.

Experimental Methods

General Procedure for Amide Coupling

To a solution of O-acetyl mandelic acid (2.0 mmol, 1.0 equiv) in dichloromethane (10 mL) was added the appropriate aminophenol derivative (2.0 mmol, 1.0 equiv). The reaction mixture was cooled in an ice bath, and N-(3-dimethylaminopropyl)-N′-ethylcarbodiimide (2.2 mmol, 1.1 equiv) was added. The resulting mixture was allowed to warm to room temperature and was stirred for 18 h. Reaction progress was monitored by thin-layer chromatography (TLC).

Upon consumption of the starting material, the reaction mixture was treated with 1 M aqueous HCl, and the organic and aqueous layers were separated. The organic layer was washed with saturated aqueous $NaHCO_3$ solution followed by brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography using hexanes/ethyl acetate (1:1, v/v) as the eluent. Fractions containing the desired product were combined and concentrated under reduced pressure to afford the corresponding amide

2-(benzyl(4-hydroxyphenyl)amino)-2-oxo-1-phenylethyl acetate 3a (85% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.84 (s, 1H), 7.41 – 7.04 (m, 12H), 6.98 – 6.64 (m, 2H), 5.94 (s, 1H), 4.99 (d, *J* = 14.4 Hz, 1H), 4.74 (d, *J* = 14.4 Hz, 1H), 2.13 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.30, 169.59, 157.43, 136.53, 133.54, 131.61, 130.05, 129.37, 128.76, 128.61, 128.56, 128.46, 127.52, 116.26, 74.30, 54.06, 20.74.

2-((4-fluorobenzyl)(4-hydroxyphenyl)amino)-2-oxo-1-phenylethyl acetate 3b (87% yield)**:** ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.75 (s, 1H), 7.40 – 7.21 (m, 3H), 7.20 – 7.05 (m, 5H), 7.00 – 6.67 (m, 5H), 5.91 (s, 1H), 5.00 (d, *J* = 14.4 Hz, 1H), 4.66 (d, *J* = 14.4 Hz, 1H), 2.14 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.44, 169.66, 162.22, 157.44, 133.37, 132.32, 131.43, 130.38, 130.06, 129.46, 128.71, 128.65, 116.32, 115.34, 74.31, 53.30, 20.73.

^{19}F NMR (100 MHz, Chloroform-d) δ 114.54.

2-((4-hydroxyphenyl)(4-(trifluoromethyl)benzyl)amino)-2-oxo-1-phenylethyl acetate 3c (78% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (s, 1H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.43 – 7.23 (m, 6H), 7.24 – 7.09 (m, 3H), 6.86 (s, 2H), 5.96 (s, 1H), 5.12 (d, *J* = 14.8 Hz, 1H), 4.74 (d, *J* = 14.8 Hz, 1H), 2.15 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.50, 170.01, 157.55, 140.62, 133.22, 131.59, 129.90, 129.84, 129.54, 128.74, 128.69, 128.65, 125.44, 122.80, 116.43, 74.29, 53.73, 20.65.

^{19}F NMR (100 MHz, Chloroform-d) δ -62.37.

2-((4-hydroxyphenyl)(4-methoxybenzyl)amino)-2-oxo-1-phenylethyl acetate 3d (83% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.84 (s, 1H), 7.35 – 7.29 (m, 1H), 7.29 – 7.22 (m, 3H), 7.15 (dt, *J* = 7.0, 1.5 Hz, 2H), 7.10 – 7.04 (m, 3H), 6.80 – 6.72 (m, 4H), 5.91 (s, 1H), 4.93 (d, *J* = 14.2 Hz, 1H), 4.69 (d, *J* = 14.2 Hz, 1H), 3.71 (s, 3H), 2.13 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.31, 169.44, 158.98, 157.41, 133.57, 131.48, 130.17, 130.05, 129.36, 128.75, 128.62, 116.24, 113.84, 74.33, 55.26, 55.14, 53.39, 20.75.

2-((4-bromobenzyl)(4-hydroxyphenyl)amino)-2-oxo-1-phenylethyl acetate 3e (82% yield): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (s, 1H), 7.40 – 7.29 (m, 4H), 7.30 – 7.19 (m, 2H), 7.20 – 7.12 (m, 2H), 7.10 – 6.98 (m, 3H), 6.84 (m, 2H), 5.91 (s, 1H), 4.97 (d, *J* = 14.5 Hz, 1H), 4.65 (d, *J* = 14.6 Hz, 1H), 2.14 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.43, 169.75, 157.46, 135.57, 133.30, 131.61, 131.47, 130.33, 130.01, 129.52, 128.71, 128.69, 121.56, 116.38, 74.28, 53.49, 20.79.

General Procedure for Deacetylation of Acetate Esters

The appropriate acetate ester **3** (1.0 mmol, 1.0 equiv) was dissolved in methanol (5 mL), and K_2CO_3 (415 mg, 3.0 mmol, 3.0 equiv) was added. The resulting suspension was stirred at room temperature for 18 h, and reaction progress was monitored by TLC. Upon complete consumption of the starting material, the reaction mixture was poured into water and extracted with dichloromethane (3 × 15 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure to afford the corresponding free alcohol **4**. The products were obtained and were used in the subsequent oxidative dearomatization without further purification. The formation of the expected deprotected intermediates were supported by ^{1}H NMR analysis. Because the intermediates was not purified, complete spectroscopic characterization was not performed**.**

N-benzyl-2-hydroxy-N-(4-hydroxyphenyl)-2-phenylacetamide 4a: ^{1}H NMR (500 MHz, Chloroform-d) δ 7.28-7.20 (m, 5H), 7.18 – 7.09 (m, 5H), 6.95 – 6.80 (m, 2H), 6.57 (m, 2H), 4.95 (s, 1H), 4.94 (d, J = 14.1 Hz, 1H), 4.73 (d, J = 14.1 Hz, 1H).

2-hydroxy-N-(4-hydroxyphenyl)-N-(4-methoxybenzyl)-2-phenylacetamide 4d: ^{1}H NMR (500 MHz, Chloroform-d) δ 7.24 – 7.11 (m, 3H), 7.04 (d, J = 8.6 Hz, 2H), 6.88 – 6.81 (m, 2H), 6.76 (d, J = 8.6 Hz, 2H), 6.65 (m, 4H), 4.91 (s, 1H), 4.88 (d, J = 14.0 Hz, 1H), 4.66 (d, J = 14.0 Hz, 1H), 3.77 (s, 3H).

General Procedure for Oxidative Dearomatization and Intramolecular Cyclization

To a solution of the appropriate free alcohol **4** (1.0 mmol, 1.0 equiv) in 2,2,2-trifluoroethanol (TFE, 5 mL; 0.20 M) at room temperature was added (diacetoxyiodo)benzene (PIDA; 355 mg, 1.1 mmol, 1.1 equiv). The reaction mixture was stirred at room temperature for 1 h under air, and reaction progress was monitored by TLC until complete consumption of the starting material was observed.

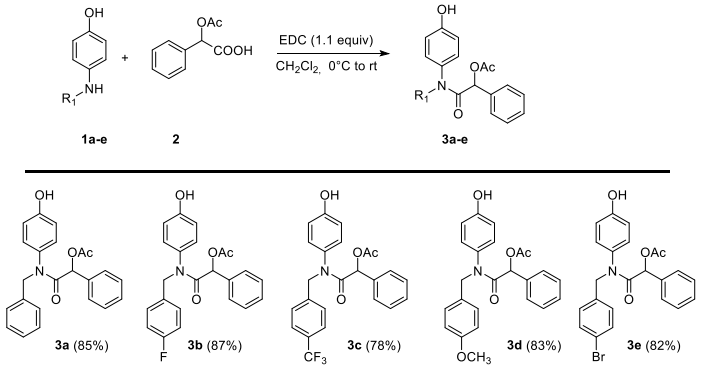
The reaction mixture was then poured into water and extracted with dichloromethane (3 × 15 mL). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography using hexanes/ethyl acetate (1.5:1, v/v) as the eluent to afford the corresponding 4-oxazolidinone cyclohexadienone **5**.

4-benzyl-2-phenyl-1-oxa-4-azaspiro[4.5]deca-6,9-diene-3,8-dione 5a (80% yield): ^{1}H NMR (500 MHz, Chloroform-d) δ 7.49 (d, J = 7.0 Hz, 2H), 7.47 – 7.32 (m, 4H), 7.22 (m, 2H), 7.16 (dd, J = 6.6, 2.9 Hz, 2H), 6.53 (dd, J = 9.9, 3.1 Hz, 1H), 6.43 (dd, J = 9.9, 3.1 Hz, 1H), 6.15 (d, J = 9.9 Hz, 2H), 5.50 (s, 1H), 4.50 (d, J = 15.1 Hz, 1H), 4.36 (d, J = 15.1 Hz, 1H).

^{13}C NMR (126 MHz, Chloroform-d) δ 184.18, 170.02, 144.87, 144.08, 136.30, 135.82, 131.33, 130.52, 129.11, 128.98, 128.90, 128.79, 128.36, 86.31, 44.39.

4-(4-methoxybenzyl)-2-phenyl-1-oxa-4-azaspiro[4.5]deca-6,9-diene-3,8-dione 5d (85% yield): ^{1}H NMR (500 MHz, Chloroform-d) δ 7.60 – 7.45 (m, 2H), 7.46 – 7.35 (m, 3H), 7.09 (d, J = 8.6 Hz, 2H), 6.78 (d, J = 8.6 Hz, 2H), 6.59 – 6.49 (m, 1H), 6.46 – 6.37 (m, 1H), 6.18 (d, J = 9.8 Hz, 2H), 5.48 (s, 1H), 4.45 (d, J = 14.9 Hz, 1H), 4.32 (d, J = 15.0 Hz, 1H), 3.78 (s, 3H).

^{13}C NMR (126 MHz, Chloroform-d) δ 184.29, 169.91, 159.65, 145.07, 144.28, 135.90, 131.25, 130.47, 130.31, 128.99, 126.53, 114.21, 86.30, 78.10, 55.45, 43.88.



Scheme 1. EDC-mediated coupling of O-acetyl mandelic acid with aminophenol derivatives.

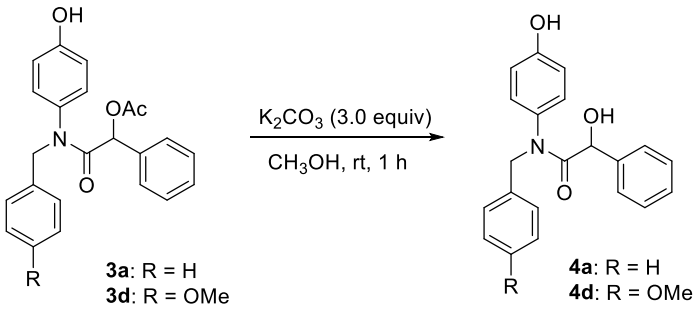
Results and Discussion

Amide Coupling and Substrate Preparation

We began our investigation by preparing a series of aminophenol-derived substrates containing a protected pendant oxygen nucleophile. O-Acetyl mandelic acid was coupled with five aminophenol derivatives using EDC as the coupling reagent (Scheme 1). Under these conditions, acylation occurred selectively at nitrogen to afford the corresponding amides **3a-3e**.

The assignment of the N-acylation products was supported by the characteristic downfield shift of the N-benzylic protons relative to the corresponding starting materials. Specifically, these resonances shifted from approximately δ 4.1–4.2 ppm in the starting aminophenols to δ 4.7–4.9 ppm in the products, consistent with formation of the desired amide through N-acylation rather than O-acylation of the phenolic group.

Importantly, this coupling provides substrates containing both the aminophenol motif required for oxidative dearomatization and a masked pendant oxygen nucleophile for subsequent intramolecular cyclization. The efficient formation of **3a-3e** (78-87% yield) therefore established a convenient route to the substrate class required to evaluate the proposed oxygen-directed oxidative cyclization.



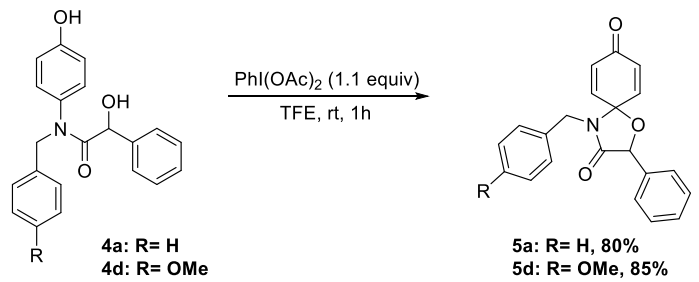
Scheme 2. Deacetylation of model substrates 3a and 3d.

Although five amide derivatives (**3a–3e**) were synthesized, the subsequent deacetylation and oxidative cyclization studies focused on two representative substrates to establish the feasibility of the proposed synthetic strategy.

Deacetylation

Compounds **3a** and **3d** were initially selected as representative substrates to establish conditions for unmasking the pendant oxygen nucleophile and evaluating the subsequent oxidative transformation. Treatment of **3a** and **3d** with K_2CO_3 in methanol at room temperature efficiently removed the acetate protecting group to afford the corresponding secondary alcohols **4a** and **4d** in quantitative yield (Scheme 2).

The mild basic conditions effected deacetylation without detectable decomposition of the aminophenol-derived amide framework. Formation of the free alcohols was supported by the disappearance of the acetate methyl resonance at approximate 2.13 ppm in the proton NMR spectra. The isolated products were of sufficient purity to be used directly in the oxidative dearomatization step without additional purification.

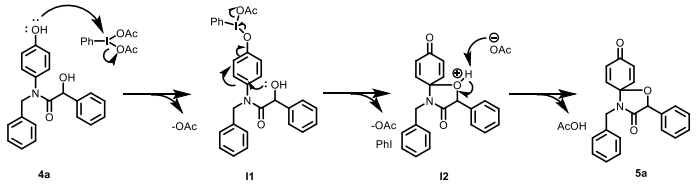


Scheme 3. PIDA-mediated oxidative dearomatization and intramolecular O-cyclization of 4a and 4d.

These results established a straightforward two-step sequence from racemic O-acetyl mandelic acid and the aminophenol derivatives to substrates containing both the oxidizable phenolic unit and the free pendant hydroxy group required for the proposed intramolecular O-cyclization.

Oxidative Dearomatization and Intramolecular O-Cyclization

With the free alcohol substrates in hand, we next investigated the key oxidative dearomatization/cyclization step. The central question was whether the pendant secondary alcohol would function as an effective intramolecular nucleophile toward the oxidatively activated phenolic ring and thereby generate the targeted 4-oxazolidinone cyclohexadienone framework. PIDA on its own is a mild oxidant and generally does not efficiently or cleanly oxidize simple unactivated alcohols[25].



Scheme 4. Proposed pathway for PIDA-mediated oxidative dearomatization.

Treatment of **4a** with PIDA (1.1 equiv) in TFE at room temperature resulted in complete consumption of the starting material within 1 h. Following purification by flash chromatography, cyclized product **5a** was isolated in 80% isolated yield. Under the same conditions, substrate **4d** afforded **5d** in 85% isolated yield.

Proposed Reaction Pathway

A plausible mechanistic pathway for the formation of 4-oxazolidinone cyclohexadienone **5a** is outlined in Scheme 4. Treatment of phenolic substrate **4a** with **PIDA** is proposed to initiate the reaction through formation of electrophilic iodine(III) intermediate **I1**. Intramolecular attack of the tethered hydroxyl group at the ipso position of the activated phenol generates a new C-O bond, leading to five-membered ring closure while concomitantly inducing oxidative dearomatization of the aromatic ring. This process affords oxonium intermediate **II2**, which upon deprotonation delivers the corresponding 4-oxazolidinone cyclohexadienone **5a**.

Conclusion

In conclusion, we have established a proof-of-concept approach to 4-oxazolidinone cyclohexadienones through amide coupling of O-acetyl mandelic acid with aminophenol derivatives, deacetylation, and PIDA-mediated oxidative dearomatization/intramolecular O-cyclization. Model substrates **4a** and **4d** underwent the key oxidative transformation to afford the corresponding cyclized products **5a** and **5d** in 80 and 85% yield, respectively, demonstrating the feasibility of pendant alcohol trapping of an oxidatively activated phenolic system. The formation of these products is consistent with intramolecular O-nucleophilic ipso cyclization following oxidative dearomatization, although further studies will be required to establish the detailed reaction mechanism. Expansion of the substrate scope and investigation of the stereochemical features of the transformation will be important for defining the generality and synthetic utility of this approach.

References

1. Wookey, A.; Turner, P. J.; Greenhalgh, J. M.; Eastwood, M.; Clarke, J.; Sefton, C., *Clinical Microbiology and Infection* **2004**, *10* (3), 247–254.
2. Trepos, R.; Cervin, G.; Hellio, C.; Pavia, H.; Stensen, W.; Stensvåg, K.; Svendsen, J.-S.; Haug, T.; Svenson, J., *Journal of Natural Products* **2014**, *77* (9), 2105–2113.
3. Tadesse, M.; Strøm, M. B.; Svenson, J.; Jaspars, M.; Milne, B. F.; Tørfoss, V.; Andersen, J. H.; Hansen, E.; Stensvåg, K.; Haug, T., *Organic Letters* **2010**, *12* (21), 4752–4755.
4. Macherla, V. R.; Liu, J.; Sunga, M.; White, D. J.; Grodberg, J.; Teisan, S.; Lam, K. S.; Potts, B. C. M., *Journal of Natural Products* **2007**, *70* (9), 1454–1457.
5. A New 4-Oxazolidinone from Sorghum Halepense (L.) Pers. *Records of Natural Products* **2015**, *9* (2), 247–250.
6. Crowley, B. M.; Stump, C. A.; Nguyen, D. N.; Potteiger, C. M.; McWherter, M. A.; Paone, D. V.; Quigley, A. G.; Bruno, J. G.; Cui, D.; Culberson, J. C.; Danziger, A.; Fandozzi, C.; Gauvreau, D.; Kemmerer, A. L.; Menzel, K.; Moore, E. L.; Mosser, S. D.; Reddy, V.; White, R. B.; Salvatore, C. A.; Kane, S. A.; Bell, I. M.; Selnick, H. G.; Fraley, M. E.; Burgey, C. S., *Bioorganic & Medicinal Chemistry Letters* **2015**, *25* (21), 4777–4781.
7. Fernandes, G. F. S.; Scarim, C. B.; Kim, S.-H.; Wu, J.; Castagnolo, D. *RSC Medicinal Chemistry* **2023**, *14* (5), 823–847. https://doi.org/10.1039/d2md00415a
8. Shymanska, N. V.; An, I. H.; Guevara-Zuluaga, S.; Pierce, J. G. *Bioorganic & Medicinal Chemistry Letters* **2015**, *25* (21), 4887–4889.
9. Shymanska, N. V.; An, I. H.; Pierce, J. G. *Angewandte Chemie* **2014**, *126* (21), 5505–5508.
10. Acharya, A.; Montes, K.; Jeffrey, C. S., *Organic Letters* **2016**, *18* (23), 6082–6085.
11. Shao, P.-L.; Chen, X.-Y.; Ye, S,. *Angewandte Chemie International Edition* **2010**, *49* (45), 8412–8416.
12. El Bouakher, A.; Le Goff, R.; Tasserie, J.; Lhoste, J.; Martel, A.; Comesse, S., *Organic Letters* **2016**, *18* (10), 2383–2386.
13. Zhang, K.; Yang, C.; Yao, H.; Lin, *Organic Letters* **2016**, *18* (18), 4618–4621.
14. Feng, J.; Zhao, M.; Lin, X., *The Journal of Organic Chemistry* **2019**, *84* (15), 9548–9560.
15. Shao, P.-L.; Chen, X.-Y.; Ye, S., *Angewandte Chemie International Edition* **2010**, *49* (45), 8412–8416.
16. Páhi, A.; Czifrák, K.; Kövér, K. E.; Somsák, L. *Carbohydrate Research* **2015**, *403*, 192–201.
17. Pouységu, L.; Deffieux, D.; Quideau, S., *Tetrahedron* **2010**, *66* (13), 2235–2261.
18. Pouységu, L.; Chassaing, S.; Dejugnac, D.; Lamidey, A.-M.; Miqueu, K.; Sotiropoulos, J.-M.; Quideau, S., *Angewandte Chemie International Edition* **2008**, *47* (19), 3552–3555.
19. Quideau, S.; Lyvinec, G.; Marguerit, M.; Bathany, K.; Ozanne-Beaudenon, A.; Buffeteau, T.; Cavagnat, D.; Chénedé, A., *Angewandte Chemie International Edition* **2009**, *48* (25), 4605–4609.
20. Baker Dockrey, S. A.; Lukowski, A. L.; Becker, M. R.;

Narayan, A. R. H., *Nature Chemistry* **2018**, *10* (2), 119–125.
21. Quideau, S.; Pouységu, L.; Deffieux, D., *Synlett* **2008**, *2008* (04), 467–495.
22. Ding, Q.; Ye, Y.; Fan, R.,*Synthesis* **2012**, *45* (01), 1–16.
23. Kita, Y.; Tohma, H.; Kikuchi, K.; Inagaki, M.; Yakura, T., *The Journal of Organic Chemistry* **1991**, *56* (1), 435–438.
24. Do, D. T., *The Journal of Organic Chemistry* **2025**, *90* (1), 529–536.
25. Bingham, M.; Pradhan, T. R.; Bhattacherjee, D.; Alkahtani, R.; Kavanagh, P.; Wirth, T.; Dingwall, P. *J. Am. Chem. Soc.* **2026**, *148* (8), 8852–8862.