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Formation of Polycyclic Lactones through a Ruthenium-Catalyzed Ring-Closing Metathesis/Hetero-Pauson−Khand Reaction Sequence

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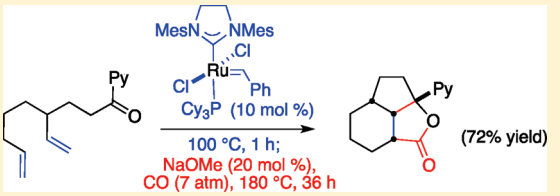
Supporting Information

ABSTRACT: Processes that form multiple carbon−carbon bonds in one operation can generate molecular complexity quickly and therefore be used to shorten syntheses of desirable molecules. We selected the hetero-Pauson−Khand (HPK) cycloaddition and ring-closing metathesis (RCM) as two unique carbon−carbon bond-forming reactions that could be united in a tandem ruthenium-catalyzed process. In doing so, complex polycyclic products can be obtained in one reaction vessel from acyclic precursors using a single ruthenium additive that can catalyze sequentially two mechanistically distinct transformations.

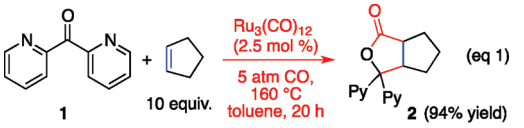


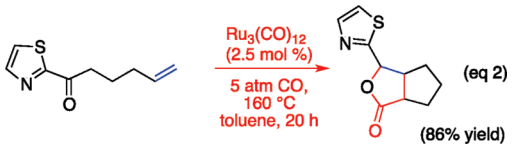
INTRODUCTION

Tandem catalysis is a process in which a substrate is transformed by two or more mechanistically distinct transformations in a single reaction vessel with all the catalysts present at the outset.[1] Since two steps are replaced with one, this strategy allows for the controlled generation of molecular complexity with a significant reduction of energy, waste stream, time, materials, and overhead costs. While there are several examples of ruthenium-catalyzed tandem processes involving olefin metathesis[2] followed either by hydrogenation,[3] isomerization,[4] or oxidation,[5] there are relatively few cases in which the subsequent metal-catalyzed reactions create additional carbon−carbon bonds. Representative examples include a tandem ring-closing metathesis/Kharasch addition,[6] an enyne metathesis/cyclopropanation,[7] an enyne; RCM/hydrovinylation,[8] and a cross-metathesis/hydroarylation sequence.[9] Each of these tandem processes generate new carbon−carbon bonds through two or more unique ruthenium-catalyzed mechanisms in a single reaction vessel. Considering the importance of streamlining syntheses toward complex molecular targets, we report herein a new tandem process that combines a ruthenium-catalyzed ring-closing metathesis (RCM) with a ruthenium-catalyzed [2 + 2+1] hetero-Pauson−Khand (HPK) cycloaddition.[10]

The hetero-Pauson−Khand reaction is a powerful strategy for generating functionalized polycyclic γ-lactones and γ-lactams. The earliest examples of hetero-Pauson−Khand (HPK) reactions came from the Crowe[11] and Buchwald[12] laboratories. These reports featured a titanium-mediated cycloaddition; however, more recent HPK reactions have been demonstrated using a wide variety of metal complexes as catalysts.[13]

The Murai group, in particular, explored the scope of the ruthenium-catalyzed HPK reaction.[14] Inter- and intramolecular examples of this ruthenium-catalyzed transformation are illustrated in eqs 1 and 2. In addition to outlining variables regarding the catalyst, the Murai team noted the importance of providing a chelating group adjacent to the carbonyl functionality in their cycloadditions.





RESULTS AND DISCUSSION

To develop the tandem olefin metathesis/HPK reaction sequence, the nature of the ruthenium in the two transformations is of importance. Specifically, differences in oxidation state and associated ligands about the ruthenium catalyst in the metathesis and HPK steps need to be considered. Our plan was to modify the reactivity of one of Grubbs' metathesis catalysts (**3**−**5**) through the addition of reductants and CO to convert the ruthenium species into a HPK catalyst. We selected Murai's HPK cycloaddition between di-2-pyridyl ketone (**1**) and cyclopentene (eq 1 and Scheme 1) to screen for the additives necessary to convert the olefin metathesis catalyst into a HPK active species. Considering the potential challenges of carrying out the metathesis in the presence of pyridine-containing substrates,[15] we focused our catalyst screening attention on the less costly but more thermally robust Grubbs' second-generation catalyst **4**.

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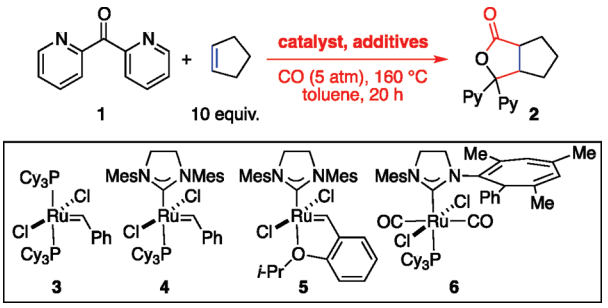
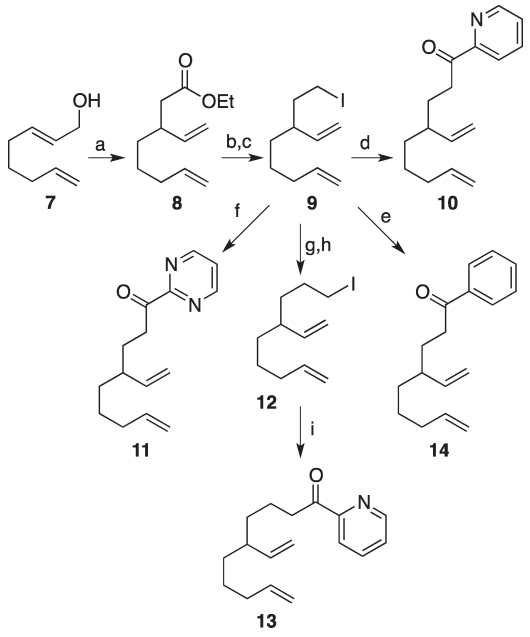
Scheme 1. Conversion of Grubbs' Olefin Metathesis Catalysts into Hetero-Pauson−Khand Active Complexes



Scheme 2. Six-Membered Ring Metathesis Substrates[a]



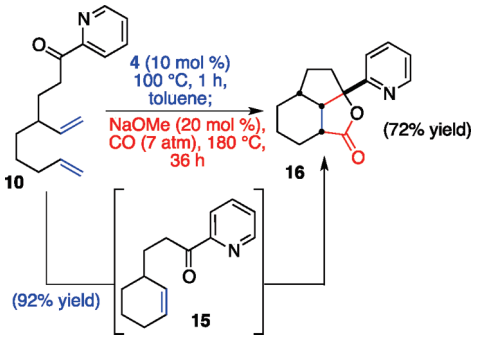
[a] Conditions: (a) $CH_3C(OEt)_3$, $CH_3CH_2CO_2H$, reflux (88% yield); (b) LAH (99% yield); (c) I_2, PPh_3 (65% yield); (d) *t*-BuLi, Et_2O, −78 °C; *N*-methoxy-*N*-methylpicolinamide; (61% yield); (e) *t*-BuLi, −78 °C, Et_2O; *N*-methoxy-*N*-methylbenzamide (26% yield); (f) Mg^0; pyrimidine-2-carbonitrile; (45% yield); (g) *t*-BuLi, −78 °C, Et_2O; 1,3,5-trioxane (47% yield). (h) PPh_3, I_2 (66% yield); (i) *t*-BuLi, −78 °C, Et_2O; *N*-methoxy-*N*-methylpicolinamide (57% yield).

Ruthenium complex **4** was first treated with CO to form Diver's complex **6** in situ.[16] That species was then subjected to reducing agents such as Zn^0, Li^0, CaH, NaH, $NaBH_4$, $NaBH_3CN$, and H_2. These additives gave no HPK activity except for NaH. While encouraging, this additive proved unreliable. Further screening of basic additives such as NaOH, KOH, and NaOMe showed NaOMe to give consistent results.[17] In this case, reproducible yields of cycloadduct **2** were obtained using 10 mol % of catalyst **4**, 10 mol % of NaOMe, and approximately 5 atm of CO. After optimization of catalyst and NaOMe loading, CO pressure, and reaction times, the yield of the HPK was increased to 73%. These optimized conditions provide a suitable starting point for development of the tandem RCM/HPK reaction sequence.

Substrate Preparation. To prepare substrates for the tandem RCM/HPK reaction sequence, we started from the commercially available dienol **7**, which was used to make iodide **9** (Scheme 2).[6a] Dienol **7** is treated under Johnson ortho-ester Claisen rearrangement conditions to yield ester **8**. The ester **8** is then reduced with LAH to give an alcohol, which is converted to iodide **9** using I_2 and PPh_3. Several tandem RCM/cycloaddition substrates could then be prepared from this common intermediate. For example, when iodide **9** is metalated using *t*-BuLi and added to the appropriate Weinreb amide,[18] the desired diene **10** is afforded in an unoptimized yield of 63%. With diene **10** in hand, the ruthenium-catalyzed intramolecular tandem RCM/HPK sequence could be explored.

The presence of Lewis basic functionalities, such as a pyridine group in substrate **10**, can cause problems in the metathesis step.[19] Coordination of the pyridine nitrogen to the ruthenium catalyst can block a necessary coordination site on the metal and inhibit metathesis activity.[20] In the case of the pyridyl ketone **10**, we found that the RCM step would proceed efficiently by heating the reaction mixture with Grubbs' second-generation catalyst **4** in toluene to 100 °C. Under these conditions, the desired RCM product **15** can be isolated in 92% yield (Scheme 3). The success of the metathesis step in the presence of the ketopyridine functionality bodes well for developing the tandem process. After considerable optimization, we found that when substrate **10** is heated with 10 mol % of catalyst **4**, then allowed to cool, reacted with

Scheme 3. Ru-Catalyzed Tandem RCM/HPK Cyclization of Diene 10



CO and NaOMe, and then reheated under a CO atmosphere, tricyclic compound **16** is produced from diene **10** as a single diastereomer (Scheme 3 and Table 1, entry 1) in a 72% yield for the tandem process.

To test the role of the pyridine functionality in the tandem process, phenyl ketone **14** was prepared (Scheme 2). Iodide **9** was metalated with *t*-BuLi and then reacted with a Weinreb amide to provide phenyl ketone **14**. As shown in eq 3, this phenyl ketone substrate **14**, along with 1 equiv of diene **10**, was then subjected to the optimized tandem RCM/HPK conditions. The resulting reaction mixture consisted of the tricyclic HPK product **16** (65% yield) derived from the pyridyl ketone substrate **10**, along with the ring-closed product **17** (80% yield) produced from phenyl ketone **14**. No HPK product derived from phenyl ketone **14** was observed. This indicates that the pyridyl ketone functionality does not serve in an intermolecular sense as a ligand that modifies the overall

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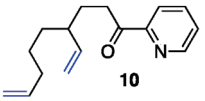
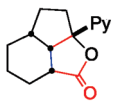
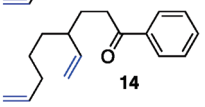
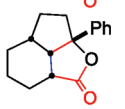
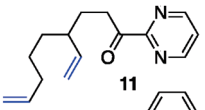
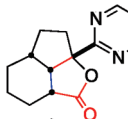
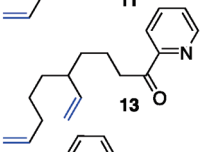
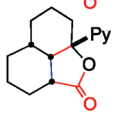
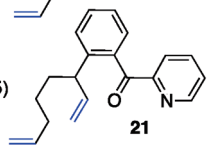
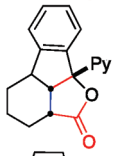
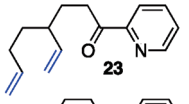
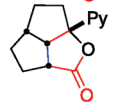
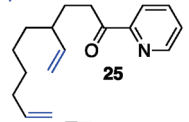
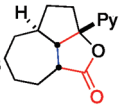
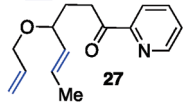
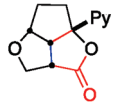
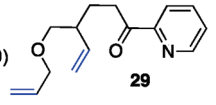
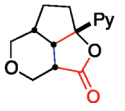
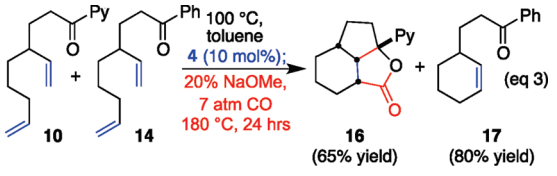
Table 1. RCM/Cycloaddition Results

Entry	Substrate	Product[a]	Yield
(1)			72%[b]
(2)			0%
(3)			0%
(4)			<5%
(5)			61%
(6)			76%
(7)			71%
(8)			51%
(9)			44%

[a] Conditions: (a) **4** (10 mol %), 100 °C, toluene; NaOMe (20 mol %), CO (7 atm), 180 °C, 36 h; (b) 24 h cycloaddition.

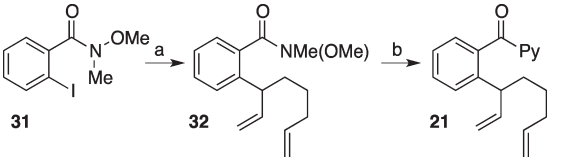
reactivity of the HPK catalyst but appears to be a necessary component of the substrate in the intramolecular HPK cycloaddition step.



10 14 16 (65% yield) 17 (80% yield)

To further explore the role of the pyridine functionality in the tandem process, the less basic pyrimidine variant **11** was prepared. The pyrimidine substrate was also accessed from iodide **9** through Grignard formation and addition to pyrimidine-2-carbonitrile. When the resulting pyrimidyl ketone **11** was submitted to the RCM/HPK conditions only the RCM product was observed (Table 1, entry 3). Apparently, the cycloaddition step is sensitive to the Lewis basicity of the chelating functionality adjacent to the carbonyl group. Additional studies are necessary to better understand the electronic and steric variability allowed in this region of the substrate.

Scheme 4. Synthesis of Substrate 21[a]



31 32 21

[a] Conditions: (a) isopropyl Grignard; CuCN·2LiCl, (*E*)-8-bromoocta-1,6-diene (1.2:1 $S_N2':S_N2$, 44% yield of **32**); (b) 2-bromopyridine, *n*-BuLi (64% yield).

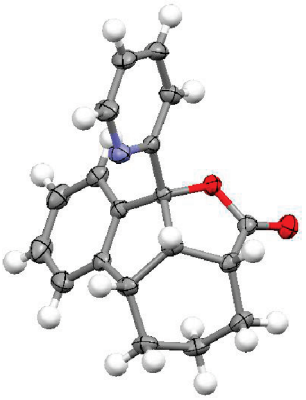


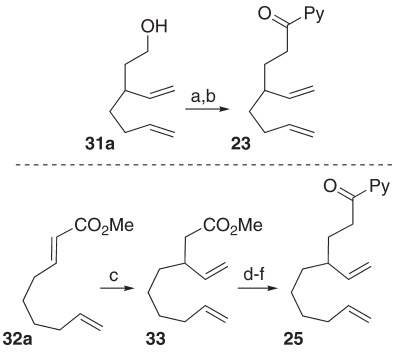
Figure 1. Crystal structure of **22**.

The effects of a longer tether length on the HPK were next examined. Again, access to the desired substrate **13** was realized from intermediate **9**. As summarized in Scheme 2, iodide **9** was homologated to iodide **12** by treatment with *t*-BuLi and addition of the resulting lithiated compound to 1,3,5-trioxane to generate the homologated alcohol. The alcohol was then converted to iodide **12** by treatment with I_2 and PPh_3. Iodide **12** was then reacted with *t*-BuLi and the appropriate Weinreb amide to form pyridyl ketone **13**. When substrate **13** was submitted to the optimized RCM/HPK conditions, the product mixture consisted mainly of the RCM product with possible trace amounts of the desired cycloadduct **20**. These results suggest that this substrate may be slower to undergo the HPK cycloaddition than the shorter tethered analogues.[14e]

To investigate additional parameters and expand the scope of the tandem process, several other substrates were synthesized. For example, the role of the ketone and its tether in the HPK step was examined through the preparation of a substrate with an aromatic, conformationally restricted, nonenolizable ketone **21**. As shown in Scheme 4, substrate **21** was prepared by allylation of iodide **31**[21] to give a slight preference for the branched Weinreb amide **32**, along with considerable amounts of the undesired linear substrate. Treatment of Weinreb amide **32** with 2-lithiopyridine resulted in the formation of pyridyl ketone **21**.

When diene **21** was subjected to the tandem RCM/HPK conditions, tetracyclic compound **22** was generated in 61% yield (Table 1, entry 5). The slight decrease in yield compared to the formation of **16** may be due to the additional rigidity of this aromatic system. In any case, spectroscopic studies on this product indicated that the relative stereochemical outcome of this cycloaddition proceeded to that of cycloadduct **16**.[22] As shown in Figure 1, a crystal structure was obtained to aid in the

Scheme 5. Syntheses of Five- and Seven-Membered Ring-Containing Substrates 23 and 25[a]



[a] Conditions: (a) I_2, PPh_3 (76% yield); (b) *t*-BuLi, Et_2O, −78 °C; *N*-methoxy-*N*-methylpicolinamide (38% yield); (c) vinylmagnesium chloride, CuI, TMSCl (76% yield); (d) LAH (89% yield); (e) I_2, PPh_3 (75% yield); (f) *t*-BuLi, Et_2O, −78 °C; *N*-methoxy-*N*-methylpicolinamide (55% yield).

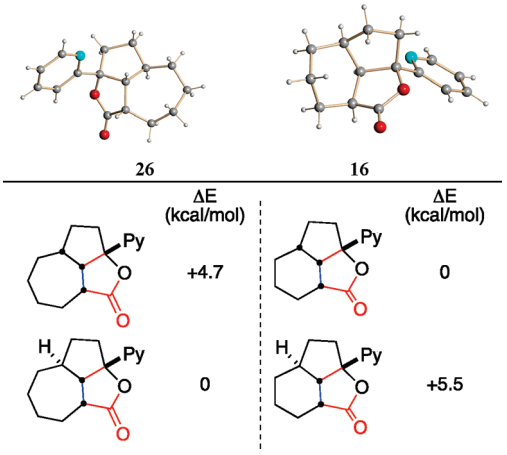


Figure 2. Crystal structures and relative energy differences (MM2) for stereoisomers of cycloadducts **26** and **16**.

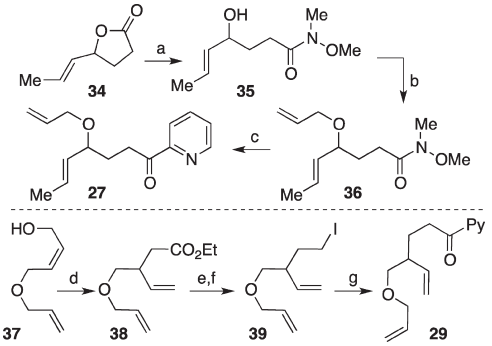
analysis of this system. The sole diastereomer formed possesses a *cis*-relationship between all of the ring junctions and the pyridyl ring functionality.

As shown in Scheme 5, the precursor to the five-membered ring variant **23** was synthesized from known alcohol **31a**[23] by converting it to iodide followed by treatment with *t*-BuLi and addition to *N*-methoxy-*N*-methylpicolinamide. Submission of substrate **23** to the same conditions as **10** resulted in the formation of the tricyclic lactone **24** in 76% yield (Table 1, entry 6).

With the success of both the five- and six-membered metathesis ring products, the synthesis of the seven-membered ring variant **25** became of interest. Production of **25** was accomplished through the pathway also outlined in Scheme 5. Enone **32a** was treated with vinyl Grignard in the presence of CuI resulting in a 1,4-addition.[24] The resulting ester **33** was reduced with $LiAlH_4$ to form an alcohol, which in turn was iodinated using I_2 and PPh_3. Metalation of the resulting iodide with *t*-BuLi and addition to the appropriate Weinreb amide provided pyridyl ketone **25**.

Submission of pyridyl ketone **25** to the tandem RCM/cycloaddition conditions resulted in the formation of tricyclic lactone **26** in 71% yield (Table 1, entry 7). NMR spectroscopy

Scheme 6. Synthesis of Substrates 27 and 29[a]



[a] Conditions: (a) HN(Me)OMe·HCl, $AlMe_3$ (57% yield); (b) NaH, allyl bromide (54% yield); (c) *n*-BuLi, 2-bromopyridine (53% yield); (d) $CH_3C(OEt)_3$, $CH_3CH_2CO_2H$ (75% yield); (e) LAH, Et_2O (52% yield); (f) I_2, PPh_3 (50% yield); (g) *t*-BuLi; *N*-methoxy-*N*-methylpicolinamide (38% yield).

and single-crystal X-ray diffraction studies indicated a difference in the stereochemical outcome for the intramolecular cycloaddition of the seven-membered ring-containing substrate (Figure 2). The five- and six-membered rings **16** and **24** resulted in the bridgehead protons having a *syn*-stereochemical relationship; however, increasing the size of the metathesis ring resulted in an inversion of the relative stereochemistry of the bridgehead carbon.

The relative stereochemistry of these ring systems is established in the HPK reaction. In as much as the intermediate ruthenacycles in the HPK cycloadditions resemble the products, we determined the relative energies of these cycloadducts and their corresponding diastereomers through MM2 and DFT calculations (Figure 2). In both the six- and seven-membered ring examples, the lower energy diastereomers are the products observed.

The ruthenium-catalyzed HPK work described by Murai indicates that olefin isomerization can, at times, lead to undesired side products.[14] To test whether this would be an issue with our tandem process, we prepared and tested substrates in which an allylic ether linkage is present in the ring generated through RCM. As shown in Scheme 6, access to these systems is possible from the known lactone **34**.[25] Conversion of **34** to Weinreb amide **35** and allylation of the resulting free alcohol by treatment with NaH and allyl bromide generated diene **36**. This diene was then treated with lithiated 2-bromopyridine to provide the desired pyridyl ketone **27**.

Submission of pyridyl ketone **27** to the tandem RCM/HPK conditions resulted in the formation of tricyclic lactone **28** in 51% yield (Table 1, entry 8). Analysis of the crude ^1H NMR spectrum suggested that the primary side product is the isomerized disubstituted enol ether with the olefin conjugated to the ether linkage.[26] The side product was not stable to our purification conditions.

To check whether the isomerization side path is affected by metathesis ring size, a six-membered ether tethered ring was also synthesized (Scheme 6). Access to this ring-size variant started by treating the known alcohol **37**[27] under the Johnson ortho-ester Claisen rearrangement conditions to form ethyl ester **38** in 75% yield. The ester was then reduced with $LiAlH_4$ to form an alcohol in 52% yield. Conversion of the alcohol to the iodide resulted in the formation of **39** in 50% yield. Lithiation of that iodide with *t*-BuLi and addition of the Weinreb amide of

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2-pyridyl carboxylate provided pyridyl ketone **29** in an unoptimized 38% yield.

Submission of pyridyl ketone **29** to tandem HPK conditions resulted in the formation of tricyclic structure **30** in 44% yield (Table 1, entry 9). Once again the primary side product seems to be the enol ether. The lower yield as compared to five-membered ring **27** is perhaps due to a more facile olefin isomerization.

CONCLUSION

We have demonstrated that the popular Grubbs' second-generation, ruthenium-based, olefin metathesis catalyst **4** can be converted in situ into a catalyst that affects a hetero-Pauson−Khand reaction by treatment with CO followed by reduction with NaOMe. This advancement has allowed for the introduction of a tandem metathesis/HPK reaction sequence. The net result is a process that converts acyclic, carbonyl-containing dienes into polycyclic, lactone-containing ring systems with the addition of one ruthenium precatalyst in a single reaction vessel.

EXPERIMENTAL SECTION

General Experimental Methods. Starting materials and reagents were purchased from commercial suppliers and used without further purification except as follows: Grubbs' second-generation olefin metathesis catalyst **4** was purified by silica gel chromatography (20% Et_2O in hexanes) to isolate the intensely colored band (cranberry red); tetrahydrofuran and CH_2Cl_2 were dried on alumina columns using a solvent dispensing system;[28] hexanes were distilled prior to use in chromatography. Dry methanol was prepared by distillation from $Mg(OMe)_2$. Sodium methoxide solution (0.50 M) was prepared immediately prior to use by dissolving sodium hydride (12 mg, 0.50 mg) in dry methanol (1.0 mL). All reactions were conducted in oven- (135 °C) or flame-dried glassware under an inert atmosphere of dry nitrogen. Carbon monoxide pressurized reactions were run in a pressure vessel. The silica gel (230−400 mesh) used for purification was oven-dried before use.

General Procedure for the Tandem Ring-Closing Metathesis/Hetero-Pauson−Khand Reaction. Inside a nitrogen atmosphere drybox, a magnetic stir bar was placed in an oven-dried glass pressure vessel and the vessel was capped with a rubber septum. The edges of the septum were sealed with electrical tape, and the tube was removed from the drybox and placed under positive N_2 pressure. To the tube was added a mixture of diene (0.15 mmol) and toluene (1.5 mL) by syringe, followed by a mixture of Grubbs' catalyst **4** (13 mg, 0.015 mmol) and toluene (1.5 mL). The tube was placed in an oil bath and warmed to 100 °C. After 1 h, heating was discontinued, and the tube was allowed to cool for 30 min. At that time, CO was sparged into the reaction mixture for 3 min followed by NaOMe (60 μL, 0.5 M in MeOH, 0.03 mmol) and a second 3 min sparge of CO. The septum was replaced with a pressure coupling, and the coupling was attached to a CO tank. The tube was placed behind a safety shield, and the tube was pressurized to 100 psig (7 atm) and released three times. On the fourth pressurization the tube was warmed to 180 °C for 30 h in an oil bath. At the end of that time, the reaction was allowed to cool to room temperature and the pressure was released. The solvent was then removed under vacuum to provide the cycloadduct, which was purified by silica gel chromatography.

General Procedure for Iodination of an Alcohol. Following the procedure of Seigal et al.,[6a] iodine was added to a stirring solution of the alcohol, triphenylphosphine, imidazole, diethyl ether, and acetonitrile at 0 °C. After 30 min the reaction was quenched with saturated sodium thiosulfate (aq). The reaction mixture was extracted with saturated sodium thiosulfate until the organic phase was colorless. The organic phase was separated, dried over $MgSO_4$ and concentrated to yield the crude product. The crude reaction mixture was purified by silica gel chromatography.

General Procedure for Addition of 2-Pyridyl Bromide to a Weinreb Amide. To a stirring solution of 2-pyridyl bromide in diethyl ether at −78 °C was added *n*-butyllithium. The reaction mixture was stirred at −78 °C for 1 h. After that time, the reaction mixture was transferred by cannula to a reaction flask containing a stirring solution of Weinreb amide and Et_2O (0.05 M) at −78 °C. The reaction was allowed to warm to room temperature overnight. At that time, the reaction was quenched with ammonium chloride (satd) and was extracted with Et_2O brine. The organic layer was dried over $MgSO_4$ and concentrated to provide the crude product, which was purified by silica gel chromatography.

1-(Pyridin-2-yl)-4-vinylnon-8-en-1-one (10). To a stirring solution of the iodine[6a] **9** (525 mg, 2.00 mmol) in Et_2O (8.3 mL) at −78 °C was added *t*-BuLi (2.50 mL, 4.00 mmol, 1.6 M in pentane). After 30 min, a solution of *N*-methoxy-*N*-methyl-2-pyridinecarboxamide[18] (300 mg, 1.80 mmol) in Et_2O (1.5 mL) was added to the reaction mixture by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the Weinreb amide had vanished by TLC (~2 h), the reaction was quenched with NH_4Cl (satd) (5 mL) and extracted with Et_2O (3 × 25 mL) and 2 N NaOH (3 × 25 mL). The organic layer was removed, dried over $MgSO_4$, and concentrated. The crude product was purified by silica gel chromatography (2 cm ×10 cm, 10% Et_2O in hexanes) to provide pyridyl ketone **10** (269 mg 61% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.48−1.29 (4H, m), 1.65 (1H, ddt J = 13.7, 9.3, 7.3 Hz), 1.84 (1H, dtd, J = 13.6, 7.9, 5.0 Hz), 2.10−1.98 (3H, m), 3.20 (2H, t, J = 7.3 Hz), 4.93 (1H, ddt, J = 10.0, 2.2, 1.3 Hz), 4.97 (1H, dt, J = 3.8, 1.6 Hz), 4.99 (1H, dd, J = 2.0, 0.6 Hz), 5.02−5.00 (1H, m), 5.55 (1H, ddd, J = 16.5, 10.8, 8.8 Hz), 5.80 (1H, ddt, J = 17.0, 10.3, 6.8 Hz) 7.45 (1H, ddd, J = 7.5, 4.8, 1.3 Hz), 7.82 (1H, td, J = 7.9, 1.7 Hz), 8.03 (1H, ddd, J = 7.9, 1.3, 0.9 Hz), 8.67 (1H, ddd, J = 4.8, 1.8, 0.9 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 202.3, 153.8, 149.1, 142.7, 139.1, 136.9, 127.0, 121.9, 115.3, 114.5, 44.0, 35.8, 34.8, 34.0, 29.2, 26.8. FTIR (NaCl, thin film): 3073 (m), 2977 (m), 2860 (m), 1698 (s), 1640 (w), 1584 (w), 1436 (w), 995 (w), 913 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 244.1711, calcd for $C_{16}H_{22}NO$ 244.1701.

1-(Pyrimidin-2-yl)-4-vinylnon-8-en-1-one (11). A stock solution of the Grignard reagent of iodide **9** was prepared by adding a solution of iodide **9** (1.60 g, 6.00 mmol) and Et_2O (3 mL) to a round-bottom flask containing magnesium turnings (160 mg, 6.60 mmol). The heterogeneous mixture was refluxed for 5 h at which time the mixture was cooled and titrated to form a solution of Grignard reagent (0.65 M).

To a 0 °C solution of pyrimidine-2-carbonitrile (85 mg, 0.80 mmol) in Et_2O (1.3 mL) was added the previously formed Grignard reagent (1.5 mL). The solution was allowed to warm to room temperature overnight. The reaction was quenched with 2 M HCl (2 mL) and was treated with NaOH (2 M) until basic. The reaction was then extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The reaction mixture was purified by silica column chromatography (2 cm ×10 cm, 50% Et_2O in hexanes to 100% Et_2O in hexanes) to provide ketone **11** (88.6 mg, 45% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.91 (2H, d, J = 5.0 Hz), 7.44 (1H, t, J = 4.8 Hz), 5.78 (1H, ddt, J = 17.0, 10.3, 6.8 Hz), 5.54 (1H, ddd, J = 16.8, 10.6, 9.0 Hz), 5.02−4.90 (4H, m), 3.20 (2H, dt, J = 9.0, 6.0 Hz), 2.10−1.98 (2H, m), 1.89 (1H, dddd, J = 13.4, 9.2, 6.6, 4.6 Hz), 1.73−1.64 (1H, m), 1.47−1.30 (5H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 199.9, 160.3, 157.6, 142.4, 138.9, 122.9, 115.3, 114.4, 43.8, 37.1, 34.6, 33.9, 28.9, 26.6. FTIR (NaCl, thin film): 3074 (m), 2976 (m), 2861 (m), 1715 (s), 1640 (w), 1563(s), 1413 (m), 1368 (w), 1324 (w), 998 (m), 914 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 245.1648, calcd for $C_{15}H_{21}N_2O$ 245.1654.

1-(Pyridin-2-yl)-5-vinyldec-9-en-1-one (13). To a −78 °C stirring solution of the iodide **9** (290 mg, 1.10 mmol) in Et_2O (4.0 mL) was added *t*-BuLi (1.80 mL, 2.40 mmol, 1.37 M in pentane). The reaction was stirred for 30 min, at which time the iodide solution was cannula transferred to a −78 °C solution of 1,3,5-trioxane (600 mg, 6.70 mmol) in Et_2O (2 mL). The reaction was stirred ∼12 h, quenched with HCl (1.2 M, 1.0 mL), and extracted with Et_2O (3 × 20 mL) and $NaHCO_3$ (satd) (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (2 cm ×10 cm, 20% Et_2O in hexanes) to provide alcohol **9a** (79.3 mg, 42% yield) as a clear colorless oil.

The general iodination procedure was followed with alcohol **9a** (87.0 mg, 0.50 mmol), iodine (196 mg, 0.80 mmol), triphenylphosphine (163 mg, 0.60 mmol), imidazole (49 mg, 0.70 mmol), acetonitrile (0.60 mL), and Et_2O (1.0 mL). The reaction mixture was purified by silica gel chromatography (2 cm ×10 cm, hexanes) to provide iodide **12** (95.3 mg, 66% yield) as a clear colorless oil.

To a solution of the iodine **12** (300 mg, 1.10 mmol) stirring in Et_2O (5.4 mL) at −78 °C was added *t*-BuLi (1.7 mL, 2.4 mmol, 1.37 M in pentane). After 1 h, a solution of 2-pyridyl Weinreb amide[18] (358 mg, 2.20 mmol) in Et_2O (0.6 mL) was added to the reaction by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the pyridyl ketone had vanished by TLC (100% Et_2O) (∼2 h), the reaction was quenched with NH_4Cl (satd) (5 mL) and extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The product was purified by silica gel chromatography (2 cm ×10 cm, 10% Et_2O in hexanes) to provide pyridyl ketone **13** (158.5 mg 57% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.67 (1H, ddd, J = 4.8, 1.8, 0.9 Hz), 8.03 (1H, dt, J = 7.9, 1.1 Hz), 7.82 (1H, td, J = 7.9, 1.8 Hz), 7.46 (1H, ddd, J = 7.7, 4.8, 1.3 Hz), 5.79 (1H, ddt, J = 16.8, 10.3, 6.6 Hz), 5.59−5.48 (1H, m), 5.02−4.90 (4H, m), 3.19 (2H, ddd, J = 8.1, 6.8, 2.2 Hz), 2.1−1.9 (3H, m), 1.8−1.6 (2H, m), 1.5−1.2 (6H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 202.1, 153.7, 149.0, 143.0, 139.2, 137.0, 127.0, 121.9, 114.6, 114.4, 44.0, 37.9, 34.8, 34.6, 34.0, 26.7, 21.9. FTIR (NaCl, thin film): 3973 (m), 2976 (m), 2947 (m), 2862 (m), 1698 (s), 1640 (m), 1436 (m), 995 (m), 912 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 258.1848, calcd for $C_{17}H_{23}N_1O_1$ 258.1857.

1-Phenyl-4-vinylnon-8-en-1-one (14). To a stirring solution of *t*-BuLi (1.74 mL, 1.70 mmol, 0.98 M in pentane) in Et_2O (2.0 mL) at −78 °C was added a solution of iodine **9** (250 mg, 0.90 mmol) in Et_2O (1.8 mL). After 30 min, a solution of *N*-benzoyl-*N*-methyl-*O*-methylhydroxylamine[29] (149 mg, 0.53 mmol) in Et_2O (0.9 mL) was added to the reaction mixture by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the *N*-benzoyl-*N*-methyl-*O*-methylhydroxylamine had vanished as judged by TLC (∼2 h), the reaction was quenched with NH_4Cl (satd) (2 mL) and extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (2 cm ×10 cm, hexanes to 10% Et_2O in hexanes) to provide phenyl ketone **14** contaminated with *tert*-butyl phenyl ketone. The mixture was submitted to 10 wt % of $AgNO_3$-impregnated silica gel (2 cm ×10 cm, 50% Et_2O in hexanes) to provide phenyl ketone **14** (59.7 mg, 26% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.98−7.92 (2H, m), 7.54 (1H, tt, J = 7.1, 1.3 Hz), 7.45 (2H, t, J = 7.9 Hz), 5.78 (1H, ddt, J = 16.8, 10.1, 6.8 Hz), 5.54 (1H, ddd, J = 17.2, 10.3, 9.0 Hz), 5.06−4.90 (4H, m), 2.95 (2H, qdd, J = 17.0, 9.3, 5.7 Hz), 2.10−1.85 (2H, m), 1.88 (1H, dddd, J = 13.6, 9.0, 6.2, 4.0 Hz), 1.61 (1H, dtd, J = 14.7, 9.2, 5.5 Hz), 1.50−1.30 (4H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 200.5, 142.5, 139.0, 137.2, 132.9, 128.6, 128.1, 115.4, 114.5, 44.0, 36.5, 34.8, 34.0, 29.3, 26.6. FTIR (NaCl, thin film): 3073 (w), 2976 (w), 2947 (w), 2894 (w), 2860 (w), 1687 (s), 1640 (w), 1580 (w), 998 (m), 912 (m), 740 (w), 689 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 243.1753, calcd for $C_{17}H_{23}O$ 243.1749.

3-(Cyclohex-2-enyl)-1-(pyridin-2-yl)propan-1-one (15). To a stirring solution of diene **10** (23.7 mg, 0.10 mmol) in toluene (1.0 mL) was added a solution of catalyst **4** (8.0 mg, 0.010 mmol) in toluene (1.0 mL). The reaction was warmed to 100 °C for 1 h. The reaction was then allowed to cool to room temperature and concentrated. The reaction mixture was purified by silica gel chromatography (1 cm × 4 cm, 10% Et_2O in hexanes) to provide pyridyl ketone **15** (19.3 mg, 92% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.70−8.66 (1H, m), 8.06−8.02 (1H, m), 7.86−7.80 (1H, m), 7.49−7.44 (1H, m), 5.73−5.60 (2H, m), 3.27 (2H, t, J = 7.7 Hz), 2.24−2.12 (1H, m), 2.02−1.94 (2H, m), 1.88−1.68 (4H, m), 1.60−1.46 (1H, m), 1.34−1.24 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 202.3, 153.6, 149.0, 136.9, 131.6, 127.5, 127.1, 121.9, 35.3, 35.0, 30.4, 29.1, 25.5, 21.6. FTIR (NaCl, thin film): 3014 (m), 2947 (m), 2860 (m), 2837 (m), 1696 (s), 1584 (w), 1436 (m), 1369 (m), 1322 (m), 1213 (m), 995 (m), 755 (w), 722 (w), 659 (w), 618 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 216.1382, calcd for $C_{14}H_{18}N_1O_1$ 216.1388.

(±)-(2a*R,2a^1*S**,5a*R**,7a*S**)-7a-(Pyridin-2-yl)octahydroindeno[1,7-*bc*]furan-2(2a^1*H*)-one (16).** The general tandem RCM/HPK procedure was followed with diene **10** (37.1 mg, 0.15 mmol). The reaction mixture was purified by silica gel chromatography (1 cm ×5 cm, 30% Et_2O in hexanes with 1% AcOH) to provide lactone **16** (26.6 mg, 72% yield) as a gray solid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.58 (1H, ddd, J = 4.8, 1.5, 0.7 Hz), 7.68 (1H, td, J = 8.1, 1.8 Hz), 7.52 (1H, dt, J = 8.1, 1.1 Hz), 7.20 (1H, ddd, J = 7.7, 4.8, 1.1 Hz), 3.17 (1H, t, J = 10.3 Hz), 2.78−2.71 (1H, m), 2.52 (1H, dt, J = 16.5, 9.5 Hz), 2.35−2.10 (3H, m), 1.80−1.72 (3H, m), 1.60 (1H, tdd, J = 13.5, 6.2, 3.3 Hz), 1.52−1.42 (2H, m), 1.38−1.28 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 179.3, 160.8, 149.3, 136.7, 122.6, 119.5, 96.4, 45.8, 39.8, 37.6, 37.1, 29.7, 26.3, 24.1, 17.5. FTIR (NaCl, thin film): 3059 (w), 3026 (w), 2915 (s), 1771 (s), 1590 (w), 1469 (w), 1436 (w), 1196 (w), 1142 (w), 1050 (w), 958 (w) cm^{-1}. HRMS (DART, M^+): found 244.1330, calcd for $C_{15}H_{18}N_1O_2$ 244.1338. Mp: 120 °C dec.

***N*-Methoxy-*N*-methyl-2-(octa-1,7-dien-3-yl)benzamide (32).** To a stirring solution of iodide **31**[30] (500 mg, 1.70 mmol) and THF (17 mL) at −78 °C was added isopropylmagnesium chloride (1.40 mL, 2.60 mmol, 1.9 M in Et_2O). The reaction was allowed to stir for 1 h at which time a solution of CuCN (310 mg, 3.40 mmol), LiCl (290 mg, 6.90 mmol), and THF (5 mL) was added by syringe. The reaction was allowed to stir for 20 min at which time a solution of 8-bromoocta-1,6-diene[31] (652 mg, 3.40 mmol) in THF (5 mL) was added to the reaction mixture, and the reaction was allowed to warm to room temperature for ∼12 h. The reaction mixture was then filtered through Celite and extracted with Et_2O (3 × 50 mL) and brine (3 × 50 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (2 cm ×10 cm, 50% Et_2O in hexanes) to provide a mixture of isomers (386.9 mg, 82%, S_N2':S_N2 1.2:1). The isomers were separated on 10 wt % of $AgNO_3$-impregnated silica gel chromatography (2 cm ×10 cm, 75% EtOAc in hexanes) to provide diene **32** (208.5 mg, 44% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.40−7.20 (4H, m), 5.98−5.86 (1H, m), 5.82−5.70 (1H, m), 5.05−4.90 (4H, m), 4.0−3.0 (4H, m), 2.04 (2H, q, J = 6.6 Hz), 1.71 (2H, q, J = 6.6 Hz), 1.48−1.18 (1H, m), 1.34−1.26 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 141.8, 141.6, 138.8, 135.0, 129.5, 127.1, 126.5, 125.7 (br), 114.5, 61.1, 46.0, 35.1, 33.8, 26.8. FTIR (NaCl, thin film): 3074.0 (m), 2974 (m), 2893 (m), 2860 (m), 1658 (s), 1459.9 (s), 1413.6 (m), 1380 (m), 991 (m), 914 (m), 735 (w) cm^{-1}. HRMS (DART, M^+): found 274.1805, calcd for $C_{17}H_{24}N_1O_2$ 274.1807.

(2-(Octa-1,7-dien-3-yl)phenyl)(pyridin-2-yl)methanone (21). The general procedure for addition of 2-bromopyridine to a Weinreb amide was followed by 2-bromopyridine (110.6 mg, 0.70 mmol) and

n-BuLi (0.20 mL, 0.42 mmol, 2.1 M in hexanes) in Et_2O (0.8 mL) followed by Weinreb amide **32** (95.6 mg, 0.35 mmol) in Et_2O (3 mL). The reaction mixture was purified by silica gel chromatography (2 cm × 10 cm, 20% Et_2O in hexanes to 33% Et_2O in hexanes) to provide pyridyl ketone **21** (64.8 mg, 64% yield). ^1H NMR ($CDCl_3$, 400 MHz): δ 8.71−8.68 (1H, m), 8.10 (1H, dt, J = 7.9, 1.1 Hz), 7.89 (1H, td, J = 7.7, 1.8 Hz), 7.50−7.44 (2H, m), 7.40−7.33 (2H, m), 7.30−7.24 (1H, m), 5.92 (1H, ddd, J = 17.4, 10.3, 7.3 Hz), 6.69 (1H, ddt, J = 17.0, 10.3, 6.8 Hz), 4.98−4.84 (4H, m), 3.50 (1H, q, J = 7.5 Hz), 1.94 (2H, q, J = 7.1 Hz), 1.70 (2H, dtd, J = 10.0, 6.8, 4.0 Hz), 1.38−1.14 (2H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 198.0, 155.0, 149.4, 143.9, 141.6, 138.8, 138.3, 136.9, 130.8, 129.1, 127.5, 126.7, 125.4, 124.2, 114.6, 114.5, 45.3, 35.2, 33.7, 26.8. FTIR (NaCl, thin film): 3060 (m), 3028 (s), 2934 (m), 2860 (w), 2292 (s), 2225 (s), 1673 (s), 1638 (s), 1580 (m), 1433 (w), 1307 (s), 1242 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 292.1699, calcd for $C_{20}H_{22}NO_1$ 292.1701.

(±)-(2a*R,2a^1*S**,5a*S**,9b*R**)-9b-(Pyridin-2-yl)-2a^1,3,4,5,5a,9b-hexahydrofluoreno[9,1-*bc*]furan-2(2a*H*)-one (22).** The general tandem RCM/HPK procedure was followed with diene **21** (44.5 mg, 0.150 mmol). The reaction mixture was purified by silica gel chromatography (1 cm × 4 cm, 40% Et_2O in hexanes) to provide lactone **22** (27.0 mg, 61% yield) as a gray solid. ^1H NMR ($CDCl_3$, 400 MHz): δ 8.56 (1H, ddd, J = 4.8, 1.6, 1.1 Hz), 7.80−7.72 (2H, m), 7.35 (2H, dqd, J = 14.6, 7.7, 1.1 Hz), 7.25−7.18 (2H, m), 7.06, (1H, d, J = 7.7 Hz), 3.78 (1H, t, J = 9.5 Hz), 3.68−3.60 (1H, m), 2.95 (1H, ddd, J = 10.3, 7.7, 2.2 Hz), 2.28−2.17 (1H, m), 1.95 (1H, dddd, J = 14.0, 8.0, 6.0, 4.0 Hz), 1.90−1.71(2H, m), 1.60−1.44 (1H, m), 1.47−1.36 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 179.6, 160.8, 149.9, 147.9, 142.5, 136.8, 130.0, 127.7, 125.5, 124.3, 122.8, 119.8, 96.9, 46.7, 41.6, 37.2, 28.2, 21.9, 18.7. FTIR (NaCl, thin film): 3060 (w), 3027 (m), 2924 (w), 1767 (s), 1587 (w), 1171 (w), 1125 (m), 751 (s), 697 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 292.1335, calcd for $C_{19}H_{18}NO_2$ 292.1338. Mp: 110 °C dec.

3-(2-Iodoethyl)hepta-1,6-diene (31b). The general iodination procedure was followed with alcohol **31a** (322.6 mg, 2.30 mmol), iodine (878 mg, 3.50 mmol), triphenyl phosphine (724 mg, 2.80 mmol), imidazole (219 mg, 3.20 mmol), acetonitrile (2.8 mL), and Et_2O (4.6 mL). The reaction mixture was purified by silica gel chromatography (2 cm × 10 cm, hexanes) to provide iodide **31b** (428 mg, 76% yield) as a clear, colorless oil. ^1H NMR ($CDCl_3$, 400 MHz): δ 5.78 (1H, ddt, J = 16.9, 10.1, 6.6 Hz), 5.44 (1H, dt, J = 18.1, 9.1 Hz), 5.12−4.92 (4H, m), 3.24 (1H, ddd, J = 9.5, 8.1, 4.9 Hz), 3.06 (1H, dt, J = 9.5, 8.1 Hz), 2.20−1.87 (4H, m), 1.73 (1H, dddd, J = 14.3, 9.7, 7.7, 4.9 Hz), 1.51−1.32 (2H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 140.8, 138.5, 116.5, 114.8, 44.5, 38.6, 33.9, 31.4, 5.1. FTIR (NaCl, thin film): 3075 (w), 2976 (s), 2936 (w), 2894 (w), 2858 (w), 1640 (s), 1418 (w), 914 (s), 754 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 251.0304, calcd for $C_9H_{16}I$ 251.0297.

1-(Pyridin-2-yl)-4-vinyloct-7-en-1-one (23). To a solution of iodide **31b** (331 mg, 1.30 mmol) stirring in Et_2O (4.7 mL) at −78 °C was added *t*-BuLi (1.60 mL, 2.70 mmol, 1.60 M in pentane). After 1 h, a solution of *N*-methoxy-*N*-methyl-2-pyridinecarboxamide[18] (300 mg, 1.80 mmol) in Et_2O (1.5 mL) was added to the reaction mixture by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the Weinreb amide had vanished by TLC (100% Et_2O) (~2 h), the reaction was quenched with NH_4Cl (satd) (5 mL) and extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was removed, dried over $MgSO_4$, and concentrated. The product was purified by silica gel chromatography (2 cm ×10 cm, 20% Et_2O in hexanes to 50% Et_2O in hexanes) to provide pyridyl ketone **23** (103.9 mg 38% yield) as a clear colorless oil. ^1H NMR ($CDCl_3$, 400 MHz): δ 8.69−8.65 (1H,m), 8.04−8.00 (1H, m), 7.82 (1H, td, J = 7.9, 1.6 Hz), 7.45 (1H, ddd, J = 7.5, 4.8, 1.3 Hz), 5.80 (1H, ddt, J = 16.9, 10.0, 6.6 Hz), 5.55 (1H, ddd, J = 16.8, 10.3, 9.0 Hz), 5.05−4.90 (4H, m), 3.20 (2H, t, J = 7.7 Hz), 2.15−1.95 (3H, m), 1.85 (1H, dtd, J = 13.4, 7.5, 4.2 Hz), 1.67 (1H, ddt, J = 16.7, 9.3, 7.5 Hz), 1.58−1.49 (1H, m), 1.40 (1H, dtd, J = 18.7, 9.3, 5.5 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 202.1, 153.7, 149.0, 142.3, 138.9, 136.9, 127.0, 121.8, 115.5, 114.4, 43.5, 35.7, 34.4, 31.5, 29.0. FTIR (NaCl, thin film) 3074 (w), 2975 (w), 2942 (w), 2893 (w), 2861 (w), 1697 (s), 1640 (w), 1584 (w), 996 (m), 914 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 230.1547, calcd for $C_{15}H_{20}NO$ 230.1545.

(2a*S,2a^1*S**,4a*R**,6a*R**)-2a-(Pyridin-2-yl)octahydro-1*H*-pentaleno[1,6-*bc*]furan-1-one (24).** The general tandem RCM/HPK procedure was followed with diene **23** (30.2 mg, 0.150 mmol). The reaction mixture was purified by silica gel chromatography (1 cm ×5 cm, 50% Et_2O in hexanes with 1% AcOH) to provide lactone **24** (23.0 mg, 76%) as a gray solid. ^1H NMR ($CDCl_3$, 400 MHz): δ 8.58 (1H, ddd, J = 4.8, 1.5, 0.9 Hz), 7.68 (1H, td, J = 7.7, 1.8 Hz), 7.53 (1H, dt, J = 7.9, 0.9 Hz), 7.20 (1H, ddd, J = 7.7, 4.9, 0.9 Hz), 3.51 (1H, t, J = 9.5 Hz), 3.08 (1H, td, J = 9.3, 4.0 Hz), 2.94 (1H, pd, J = 8.4, 4.9 Hz), 2.42 (1H, dd, J = 11.0, 7.5 Hz), 2.39 (1H, dd, J = 11.0, 7.3 Hz), 2.34−2.20 (2H, m), 2.2−2.08 (2H, m), 1.94 (1H, td, J = 13.4, 7.3 Hz), 1.67−1.56 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 180.8, 161.8, 149.4, 136.8, 122.5, 119.4, 96.5, 57.7, 47.3, 45.7, 41.8, 32.2, 32.0, 31.2. FTIR (NaCl, thin film): 3076 (w), 3051 (w), 3016 (w), 1765 (s), 1587 (w), 1468 (w), 1434 (w), 1163 (w), 1126 (w), 1001 (w), 751 (w), 696 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 230.1183, calcd for $C_{14}H_{16}NO_2$ 230.1181.

Methyl 3-Vinylnon-8-enoate (33). To a solution of CuI (4.60 g, 24.6 mmol) in THF (144 mL) stirring at −78 °C was added vinylmagnesium chloride (10.0 mL, 12.1 mmol, 1.21 M in THF). After 45 min, TMSCl (9.50 mL, 75.0 mmol) was added in one portion. Then a solution of ester **32a**[32] (700 mg, 4.20 mmol) and THF (35 mL) was added over 30 min. The reaction was stirred at −78 °C until ester **32** was gone by TLC (5% Et_2O in hexanes). When the reaction was complete, it was quenched with 1:1 solution of satd NH_4OH (aq)/satd NH_4Cl (aq) (25 mL) and extracted with the same 1:1 solution of satd NH_4OH (aq)/satd NH_4Cl (aq) with Et_2O (3 × 75 mL) until the aqueous layer was no longer blue. The organic layer was concentrated and purified by silica gel chromatography (4 cm × 10 cm, 5% Et_2O in hexanes) to provide diene **33** (718 mg, 88% yield) as a clear colorless oil. ^1H NMR ($CDCl_3$, 400 MHz): δ 5.80 (1H, ddt, J = 17.0, 10.3, 6.8 Hz), 5.70 (1H, ddd, J = 17.2, 10.3, 8.4 Hz), 5.05−4.9 (4H, m), 3.65 (3H, s), 2.56−2.45 (1H, m), 2.32 (2H, qd, J = 14.7, 6.0 Hz), 2.80−2.00 (2H, m), 1.44−1.24 (6H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 173.0, 141.1, 139,0, 115.1, 114.4, 51.5, 40.5, 40.1, 34.4, 33.8, 28.9, 26.6. FTIR (NaCl, thin film): 3076 (w), 2978 (w), 2949 (m), 2859 (m), 1741 (s), 1641 (w), 1436 (w), 1252 (m), 1164 (m), 994 (m), 914 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 197.1538, calcd for $C_{12}H_{21}O_2$ 197.1542.

3-Vinylnon-8-en-1-ol (33a). To a stirring solution of ester **33** (500 mg, 2.60 mmol) in Et_2O (3.2 mL) at −78 °C was added LAH (5.10 mL, 5.10 mmol, 1.0 M in Et_2O). The reaction was allowed to warm to room temperature over ~12 h at which time the reaction was quenched according to the procedure of Micovic by sequential addition of 0.2 mL of H_2O, 0.2 mL of 15% NaOH, and 0.6 mL of H_2O.[33] The white solid was filtered and concentrated under vacuum to provide ester **33a** (381.6 mg, 89%) as a clear colorless oil. The crude material was used without further purification. To provide analytically pure material the crude material was purified by silica gel chromatography (20% Et_2O in hexanes). H NMR ($CDCl_3$, 400 MHz): δ 5.80 (1H, ddt, J = 16.8, 10.3, 6.6 Hz), 5.56 (1H, dt, J = 18.0, 9.3 Hz), 5.04−4.90 (4H, m), 3.72−3.58 (2H, m), 2.16−1.98 (3H, m), 1.67 (1H, dtd, J = 14.1, 7.3, 4.4 Hz), 1.54−1.21 (8H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 142.9, 139.1, 114.9, 114.3, 61.3, 41.2, 38.0, 35.2, 33.9, 29.1, 26.7. FTIR (NaCl, thin film): 3353 (br), 3076 (w), 2977 (w), 2948 (w), 2862 (m), 1640 (m), 1428 (m), 1052 (m), 995 (m), 912 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 169.1599, calcd for $C_{11}H_{21}O$ 169.1592.

3-(2-Iodoethyl)nona-1,8-diene (33b). The general iodination procedure was followed with alcohol **33a** (545.1 mg, 3.20 mmol), iodine (2.00 g, 8.30 mmol), triphenylphosphine (1.00 g, 3.90 mmol), imidazole (308 mg, 4.50 mmol), acetonitrile (4.0 mL), and Et_2O (6.5 mL). The reaction mixture was purified by silica gel chromatography (2 cm × 10 cm, hexanes) to provide iodide **33b** (674 mg, 75% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 5.80 (1H, ddt, J = 16.9, 10.3, 6.6 Hz), 5.48−5.38 (1H, m), 5.09−4.91 (4H, m), 3.24 (1H, ddd, J = 9.5, 8.1, 5.0 Hz), 3.06 (1H, dt, J = 9.5, 7.9 Hz), 2.14−2.06 (1H, m), 2.04 (2H, q, J = 7.1 Hz), 1.92 (1H, dtd, J = 14.1, 8.2, 4.4 Hz), 1.72 (1H, dddd, J = 14.3, 9.5, 7.7, 4.9 Hz), 1.40−1.24 (6H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 141.2, 139.0, 116.0, 114.4, 45.0, 38.7, 34.6, 33.8, 29.1, 26.6, 5.3. FTIR (NaCl, thin film): 3075 (m), 2976 (m), 2858 (m), 1640 (m), 1418 (m), 1234 (m), 995 (m), 914 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 279.0607, calcd for $C_{11}H_{19}I$ 279.0610.

1-(Pyridin-2-yl)-4-vinyldec-9-en-1-one (25). To a stirring solution of *t*-BuLi (0.90 mL, 1.0 mmol, 1.18 M in pentane) in Et_2O (1.0 mL) at −78 °C was added iodine **33b** (150 mg, 0.50 mmol). After 30 min, a solution of *N*-methoxy-*N*-methyl-2-pyridinecarboxamide[18] (90 mg, 0.53 mmol) in Et_2O (0.5 mL) was added to the reaction mixture by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the pyridyl ketone had vanished by TLC (100% Et_2O) (∼2 h), the reaction was quenched with NH_4Cl (satd) (3 mL) and extracted with Et_2O (3 × 50 mL) and brine (3 × 50 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (2 cm ×10 cm, hexanes to 10% Et_2O in hexanes) to provide pyridyl ketone **25** (75.9 mg, 55% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.76 (1H, ddd, J = 5.2, 1.8, 0.9 Hz), 8.04 (1H, dt, J = 7.9, 1.1 Hz), 7.82 (1H, td, J = 7.7, 1.6 Hz), 7.45 (1H, ddd, J = 7.5, 4.8, 1.3 Hz), 5.80 (1H, ddt, J = 17.0, 10.3, 6.8 Hz), 5.54 (1H, ddd, J = 16.3, 10.8, 8.8 Hz), 5.02−4.90 (4H, m), 3.20 (2H, t, J = 7.7 Hz), 2.10−1.98 (3H, m), 1.89−1.79 (1H, m), 1.7−1.58 (1H, m), 1.48−1.22 (6H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 202.2, 153.6, 149.0, 142.7, 139.1, 136.8, 127.0, 121.8, 115.1, 114.3, 43.9, 35.7, 35.0, 33.9, 29.2, 29.1, 26.8. FTIR (NaCl, thin film): 3073 (m), 2975 (m), 2945 (m), 2859 (m), 1698 (s), 1640 (w), 1585 (w), 995 (m), 913 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 258.1848, calcd for $C_{17}H_{24}NO$ 258.1858.

(±)-(2a*S,2a^1*S**,4a*S**,8a*R**)-2a-(Pyridin-2-yl)decahydro-1*H*-azuleno[1,8-*bc*]furan-1-one (26).** The general tandem RCM/HPK procedure was followed with diene **25** (39.7 mg, 0.150 mmol). The reaction mixture was purified by silica gel chromatography (1 cm × 5 cm, 50% Et_2O in hexanes with 1% AcOH) to provide lactone **26** (28.1 mg, 71% yield) as a gray solid. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.60 (1H, ddd, J = 4.8, 1.7, 0.9 Hz), 7.66 (1H, td, J = 7.9, 1.8 Hz), 7.44 (1H, d, J = 8.1 Hz), 7.19 (1H, ddd, J = 7.5, 4.9, 1.1 Hz), 2.90−2.74 (2H, m), 2.41 (1H, dd, J = 13.9, 8.4 Hz), 2.28−2.16 (2H, m), 2.08−1.92 (3H, m), 1.92−1.78 (1H, m), 1.72 (1H, dd, J = 12.1, 8.6 Hz), 1.62−1.51 (1H, m), 1.36−1.16 (4H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 179.4, 162.7, 149.6, 136.6, 122.4, 118.8, 95.8, 58.5, 43.6, 42.2, 40.0, 34.6, 34.5, 31.2, 28.1, 26.0. FTIR (NaCl, thin film): 2949 (m), 2897 (m), 2860 (m), 1776 (s), 1588 (w), 1468 (w), 1435 (w), 1315 (w), 1209 (m), 1185 (m), 1152 (m), 1065 (m), 993 (m), 782 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 258.1497, calcd for $C_{16}H_{20}NO_2$ 258.1494.

(*E*,*Z*)-4-Hydroxy-*N*-methoxy-*N*-methylhept-5-enamide (35). To a stirring solution of MeNHOMe·HCl (137 mg, 1.40 mmol) in CH_2Cl_2 (2.6 mL) at 0 °C was added $AlMe_3$ (0.70 mL, 1.4 mmol, 2.0 M in toluene). The reaction mixture was stirred for 15 min, at which time a solution of lactone **34**[25] (88.3 mg, 0.7 mmol) in CH_2Cl_2 (2.6 mL) was added in one portion. The reaction was allowed to warm to room temperature over ∼12 h. The reaction was quenched with 2 M HCl (10 mL) and extracted with CH_2Cl_2 (3 × 50 mL) and brine (3 × 50 mL). The organic layer was dried over $MgSO_4$ and concentrated. The product was purified by silica gel chromatography (1 cm × 5 cm, 100% Et_2O) to provide **35** (74.6 mg, 57% yield) as a clear yellow oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 5.70 (1H, dddd, J = 15.4, 13.0, 6.6, 1.1 Hz), 5.50 (1H, ddd, J = 15.4, 6.6, 1.6 Hz), 4.16−4.08 (1H, m), 3.68 (3H, s), 3.18 (3H, s), 2.64−2.47 (2H, m), 1.92−1.78 (2H, m), 1.72−1.66 (3H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 174.9, 133.9, 133.4 (m), 126.5, 126.0 (m), 72.2, 67.0 (m), 61.3, 32.4 (m), 31.9, 31.8 (m), 28.2, 17.8. FTIR (NaCl, thin film): 3421 (b), 2963.1 (s), 2839 (w), 1633 (s), 1463 (m), 1424 (w), 1179 (m), 1125 (w), 1060 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 188.1283, calcd for $C_9H_{18}NO_3$ 188.1287.

(*E*,*Z*)-4-(Allyloxy)-*N*-methoxy-*N*-methylhept-5-enamide (36). To a solution of sodium hydride (60 wt %, 32 mg, 0.80 mmol), THF (1.5 mL), and DMF (0.3 mL) stirring at 0 °C was added a solution of alcohol **35** (47.4 mg, 0.30 mmol) and THF (1.5 mL). The reaction was allowed to stir for 1 h at which time allyl bromide (67 μL, 0.80 mmol) was added in one portion. The reaction was allowed to warm to room temperature over ∼12 h. The reaction was quenched with NH_4Cl (satd) (1 mL). The reaction was extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (1 cm ×10 cm, hexanes to 33% EtOAc in hexanes) to provide allyl ether **36** (31.3 mg, 54% yield) as a yellow oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 5.86 (1H, dddd, J = 17.2, 16.3, 11.2, 5.9 Hz), 5.63 (1H, tdd, J = 15.4, 6.6, 0.7 Hz), 5.36−5.28 (1H, m), 5.24 (1H, dq, J = 17.2, 1.7 Hz), 5.13 (1H, dq, J = 10.3, 1.3 Hz), 4.02 (1H, ddt, J = 13.0, 5.3 1.6 Hz), 3.80 (1H, ddt, J = 12.8, 5.9, 1.5 Hz), 5.77−3.65 (1H, m), 3.67 (3H, s), 3.17(3H, s), 2.50 (2H, t, J = 7.5 Hz), 1.92−1.80 (2H, m), [olefin cis: trans =1:6 δ 1.71 (3H, dd, J = 6.4, 1.7 Hz) or 1.66 (3H, dd, J = 7.0, 1.8 Hz)]. ^{13}C NMR ($CDCl_3$, 100 MHz): δ 174.4, 135.3, 131.6, 131.4, 128.8, 127.6 (m), 116.2, 79.3, 73.1 (m), 68.9, 61.2, 32.4 (m), 30.3, 30.1 (m), 27.8, 17.8, 13.5 (m). FTIR (NaCl, thin film): 2963 (s), 2861 (m), 1667 (s), 1417 (m), 1080 (m), 998 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 228.1605, calcd for $C_{12}H_{22}NO_3$ 228.1600.

(*E*,*Z*)-4-(Allyloxy)-1-(pyridin-2-yl)hept-5-en-1-one (27). The general procedure for addition of 2-bromopyridine to a Weinreb amide was followed with 2-bromopyridine (96 μL, 1.0 mmol) and *n*-BuLi (0.25 mL, 0.60 mmol, 2.3 M in hexanes) in Et_2O (2.5 mL) followed by Weinreb amide **36** (114 mg, 0.50 mmol) in Et_2O (10 mL). The reaction mixture was purified by silica gel chromatography (2 cm ×10 cm, 10% Et_2O in hexanes) to provide pyridyl ketone **27** (65.8 mg, 53% yield) as a clear colorless oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.68 (1H, ddd, J = 4.8, 1.8, 0.9 Hz), 8.02 (1H, dt, J = 7.9, 1.1 Hz), 7.82 (1H, td, J = 7.7, 1.7 Hz), 4.45 (1H, ddd, J = 7.5, 4.8, 1.3 Hz), 5.91−5.80 (1H, m), 5.69−5.58 (1H, m), 5.39−5.31 (1H, m), 5.23 (1H, dq, J = 17.2, 1.8 Hz), 5.13−5.07 (1H, m), 4.04−3.98 (1H, m), 3.28 (2H, ddd, J = 19.1, 9.6, 8.1 Hz), 2.10−1.86 (2H, m), [olefin cis:trans =1:3.8 δ 1.70 (3H, dd, J = 6.4, 1.7 Hz) or 1.65 (3H, dd, J = 6.8, 1.7 Hz)]. ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.7, 153.6, 148.9, 136.8, 135.3, 131.7, 129.0, 127.0, 121.8, 116.4, 79.6, 69.0, 33.9, 30.1, 17.8. FTIR (NaCl, thin film): 3076 (w), 2947 (m), 2860 (m), 1696 (s), 1584 (w), 1438 (w), 1080 (s), 995 (w), 923 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 246.1493, calcd for $C_{15}H_{20}NO_2$ 246.1494.

(±)-(2a*R,4a*S**,6b*S**)-6a-Pyridin-2-ylhexahydro-1,6-dioxacyclopenta[*cd*]pentalen-2(2a*H*)-one (28).** The general tandem RCM/HPK procedure was followed with diene **27** (37.4 mg, 0.150 mmol). The reaction mixture was purified by silica gel chromatography (1 cm ×5 cm, 75% Et_2O in hexanes, 1% AcOH) to provide lactone **28** (18.0 mg, 51% yield) as a brown oil. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.57 (1H, ddd, J = 4.9, 1.8, 1.1 Hz), 7.70 (1H, td, J = 9.5, 1.8 Hz), 7.53 (1H, dt, J = 7.9, 0.9 Hz), 7.22 (1H, ddd, J = 7.5, 4.8, 1.1 Hz), 4.73 (1H, ddd, J = 7.0, 5.1, 2.6 Hz), 4.46 (1H, d, J = 9.1 Hz), 3.93 (1H, dd, J = 9.2, 6.4 Hz), 3.72 (1H, dd, J = 9.2, 6.6 Hz), 3.25 (1H, ddd, J = 9.3, 6.4, 1.1 Hz), 2.48−2.40 (2H, m) 2.34−2.12 (2H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 178.5, 162.0, 149.5, 136.9, 122.7, 118.9, 95.4, 87.7, 73.7, 56.7, 47.6, 40.5, 31.5. FTIR (NaCl, thin film): 2968 (s), 2874 (s), 1775 (s), 1589 (w), 1589 (w), 1470 (w), 1435 (w), 1060 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 232.0972, calcd for $C_{13}H_{14}NO_3$ 232.0972.

Ethyl 3-(Allyloxymethyl)pent-4-enoate (38). A mixture of alcohol **37**[27] (1.38 g, 10.7 mmol), triethyl orthoacetate (13.0 mL, 75.0 mmol), and propionic acid (112 μL, 1.50 mmol) was warmed in a 130 °C oil bath for 24 h. The reaction was quenched with HCl (aq) (2 N, 15 mL) and extracted with Et_2O (3 × 50 mL) and saturated $NaHCO_3$ (aq) (3 × 50 mL). The organic layer was dried over $MgSO_4$ and concentrated. The ester **38** (1.60 g, 75% yield) was used without further purification. For purposes of characterization, the crude product was purified by silica gel chromatography (10% Et_2O in hexanes). ^1H NMR ($CDCl_3$, 400 MHz): δ 5.88 (1H, qt, *J* = 10.4, 5.5 Hz), 5.75 (1H, ddd, *J* = 18.1, 10.4, 7.9 Hz), 5.26 (1H, dq, *J* = 17.2, 1.7 Hz), 5.19−5.06 (3H, m), 4.12 (2H, q, *J* = 7.1 Hz), 3.99−3.95 (2H, m), 3.40 (1H, dd, *J* = 9.3, 5.7 Hz), 3.35 (1H, dd, *J* = 9.3, 7.1 Hz), 2.91−2.82 (1H, m), 2.55 (1H, dd, *J* = 15.1, 6.1 Hz), 2.34 (1H, dd, *J* = 15.4, 8.2 Hz), 1.24 (3H, t, *J* = 7.4 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 172.4, 138.1, 134.8, 116.8, 116.2, 72.8, 72.0, 60.4, 40.5, 36.7, 14.4. FTIR (NaCl, thin film): 3079 (w), 2981 (m), 2863 (m), 1738 (s), 1644 (w), 1420 (m), 1371 (m), 1252 (m), 1179 (m), 1102 (m), 921 (m) cm^{-1}. HRMS (DART, $[M + H]^+$): found 199.1336, calcd for $C_{11}H_{19}O_3$ 199.1334.

3-(Allyloxymethyl)pent-4-en-1-ol (38a). To a stirring solution of ester **38** (993 mg, 5.0 mmol) in Et_2O (13 mL) at −78 °C was added LAH (381 mg, 10.0 mmol). The reaction was allowed to warm to room temperature over ∼12 h and was quenched according to the procedure of Micovic by sequential addition of 0.4 mL of H_2O, 0.4 mL of 15% NaOH, and 1.2 mL of H_2O.[33] The white solid was filtered and concentrated under vacuum to provide ester **38a** (408.9 mg, 52% yield) as a clear colorless oil. The material was used without further purification. To provide analytically pure material the crude material was purified by silica gel chromatography (25% Et_2O in hexanes). ^1H NMR ($CDCl_3$, 400 MHz): δ 5.90 (1H, ddt, *J* = 17.2, 10.4, 5.7 Hz), 5.72 (1H, ddd, *J* = 17.4, 10.4, 8.4 Hz), 5.27 (1H, dq, *J* = 17.2, 1.7 Hz), 5.18 (1H, *J* = 10.4, 1.3 Hz), 5.13 (1H, dd, *J* = 1.8, 0.9 Hz), 5.07 (1H, ddd, *J* = 10.4, 1.6, 0.9 Hz), 3.99 (2H, m), 3.75 − 3.60 (2H, m), 3.44 (1H, dd, *J* = 9.2, 5.5 Hz), 3.37 (1H, dd, *J* = 9.3, 7.3 Hz), 2.55−2.45 (1H, m), 2.06 (1H, t, *J* = 5.9 Hz), 1.76 (1H, ddt, *J* = 11.7, 7.5, 5.9 Hz), 1.65 (1H, ddt, *J* = 13.9, 7.7, 6.0 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.6, 134.6, 117.3, 115.9, 74.0, 72.2, 61.2, 41.7, 35.3. FTIR (NaCl, thin film): 3418 (br), 3356 (b), 3076 (w), 2952 (m), 2872 (s), 1643 (m), 1421 (m), 1349 (m), 1057 (s), 998 (s), 919 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 157.1231, calcd for $C_9H_{17}O_2$ 157.1229.

3-(Allyloxymethyl)-5-iodopent-1-ene (39). The general iodination procedure was followed with alcohol **38a** (300 mg, 1.90 mmol), iodine (733 mg, 2.90 mmol), triphenylphosphine (905 mg, 3.50 mmol), imidazole (273 mg, 4.00 mmol), acetonitrile (2.4 mL), and Et_2O (4.0 mL). The reaction mixture was purified by silica gel chromatography (2 cm × 10 cm, 50% Et_2O in hexanes) to provide iodide **39** (254.4 mg, 50% yield) as a clear colorless oil. ^1H NMR ($CDCl_3$, 400 MHz): δ 5.90 (1H, ddt, *J* = 17.2, 10.6, 5.7 Hz), 5.60 (1H, ddd, *J* = 17.2, 10.3, 8.6 Hz), 5.26 (1H, dq, *J* = 17.2, 1.7 Hz), 5.20−5.10 (3H, m), 3.96 (2H, dq, *J* = 5.5, 1.3 Hz), 3.38 (2H, qd, *J* = 9.3, 5.9 Hz), 3.27 (1H, ddd, *J* = 9.5, 7.9, 5.1 Hz), 3.10 (1H, dt, *J* = 9.5, 8.1 Hz), 2.46 (1H, m), 2.09 (1H, dtd, *J* = 14.1, 8.1, 4.4 Hz), 1.80 (1H, dddd, *J* = 14.5, 9.3, 7.7, 5.1 Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 138.1, 134.8, 117.2, 117.0, 73.2, 72.2, 45.1, 35.3, 4.8. FTIR (NaCl, thin film): 3076 (w), 3025 (w), 2960 (m), 2862 (s), 1728 (w), 1643 (w), 1421 (w), 1099 (s), 920 (s) cm^{-1}. HRMS (DART, $[M + H]^+$): found 267.0253, calcd for $C_9H_{16}IO$ 267.0246.

4-(Allyloxymethyl)-1-(pyridin-2-yl)hex-5-en-1-one (29). To a solution of the iodine **39** (247.0 mg, 0.930 mmol) stirring in Et_2O (3.3 mL) at −78 °C was added *t*-BuLi (2.20 mL, 1.90 mmol, 0.86 M in pentane). After 1 h, a solution of *N*-methoxy-*N*-methyl-2-pyridinecarboxamide[18] (140 mg, 0.840 mmol) in Et_2O (1.5 mL) was added to the reaction mixture by syringe. The reaction was allowed to stir at −78 °C for 10 min and then allowed to warm to room temperature. When the pyridyl ketone had vanished by TLC (100% Et_2O) (∼2 h), the reaction was quenched with NH_4Cl (satd) (5 mL) and extracted with Et_2O (3 × 25 mL) and brine (3 × 25 mL). The organic layer was dried over $MgSO_4$ and concentrated. The crude product was purified by silica gel chromatography (2 cm × 10 cm, 33% Et_2O in hexanes to 50% Et_2O in hexanes) to provide pyridyl ketone **29** (103.9 mg, 38% yield) as a clear colorless oil. ^1H NMR ($CDCl_3$, 400 MHz): δ 8.68 (1H, ddd, *J* = 4.8, 1.8, 0.9 Hz), 8.02 (1H, dt, *J* = 7.9, 0.9 Hz), 7.82 (1H, td, *J* = 7.5, 1.7 Hz), 7.45 (1H, ddd, *J* = 7.5, 4.8, 1.3 Hz), 5.90 (1H, ddt, *J* = 17.2, 10.4, 5.5 Hz), 5.69 (1H, ddd, *J* = 17.2, 10.3, 8.4 Hz), 5.26 (1H, dq, *J* = 17.4, 1.8 Hz), 5.18−5.06 (3H, m), 3.98 (2H, dt, *J* = 5.5, 1.5 Hz), 3.42 (2H, d, *J* = 6.4 Hz), 3.25 (2H, t, *J* = 7.5 Hz), 2.48−2.40 (1H, m), 2.03−1.93 (1H, m), 1.77−1.66 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 201.9, 153.6, 149.0, 139.6, 136.9, 135.1, 127.0, 121.8, 116.8, 116.5, 73.9, 72.1, 44.0, 35.5, 25.6. FTIR (NaCl, thin film): 3075 (w), 2978 (w), 2952 (w), 2865 (m), 1697 (s), 1584 (w), 1365 (w), 1103 (m), 995 (m), 919 (m), 776 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 246.1505, calcd for $C_{15}H_{20}NO_2$ 246.1494.

(±)-(4a*R,7a*S**,7b*S**)-2a-Pyridin-2-yloctahydro-1*H*-2,6-dioxacyclopenta[*cd*]inden-1-one (30).** The general tandem RCM/HPK procedure was followed with diene **29** (37.1 mg, 0.150 mmol). The reaction mixture was purified by silica gel chromatography (1 cm × 5 cm, 40% Et_2O in hexanes with 1% AcOH) to provide lactone **30** (28.1 mg, 44% yield) as a gray solid. ^1H NMR ($CDCl_3$, 400 MHz): δ 8.59 (1H, ddd, *J* = 4.8, 1.6, 0.9 Hz), 7.71 (1H, td, *J* = 7.9, 1.8 Hz), 7.55 (1H, dt, *J* = 7.9, 1.1 Hz), 7.23 (1H, ddd, *J* = 7.5, 4.8, 1.3 Hz), 4.43 (1H, d, *J* = 2.1 Hz), 3.96 (1H, d, *J* = 2.1 Hz), 3.64 (1H, dd, *J* = 12.0, 3.9 Hz), 3.52 (1H, dd, *J* = 11.9, 4.2 Hz), 3.41 (1H, t, *J* = 10.1 Hz), 2.58 (1H, dd, *J* = 10.3, 4.0 Hz), 2.39−2.21 (3H, m), 2.08−1.95 (1H, m), 1.95−1.85 (1H, m). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 177.5, 160.4, 149.5, 136.9, 122.9, 119.8, 96.3, 68.4, 65.6, 43.3, 39.9, 37.7, 37.0, 28.7. FTIR (NaCl, thin film): 3053 (w), 2957 (w), 2858 (w), 1768 (s), 1589 (w), 1468 (w), 1181 (w), 1150 (w), 1119 (w), 1063 (w), 998 (w), 752 (w) cm^{-1}. HRMS (DART, $[M + H]^+$): found 246.1135, calcd for $C_{14}H_{16}NO_3$ 246.1130. Mp: 88−90 °C.

■ ASSOCIATED CONTENT

Supporting Information. X-ray crystallographic data and ^1H NMR and ^{13}C NMR spectra are provided. This material is available free of charge via the Internet at http://pubs.acs.org.

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