JOC The Journal of Organic Chemistry

Article

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Carboxylate-Enhanced Rhodium(III)-Catalyzed Aryl C−H Alkylation with Conjugated Alkenes under Mild Conditions

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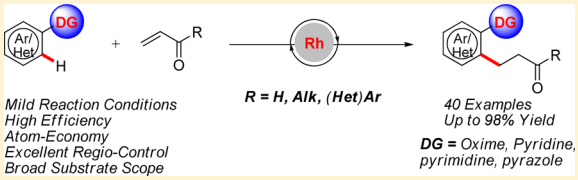
Supporting Information

ABSTRACT: Rhodium(III)-catalyzed C−H bond functionalization for the synthesis of β-aryl aldehydes and ketones from (hetero)aryl oximes, pyri(mi)dine, as well as pyrazoles and α,β-unsaturated carbonyl compounds has been developed under exceedingly mild reaction conditions. Thus, the versatile rhodium(III) catalysis features high step- and atom-economy, oxidant-free reaction conditions, and broad substrate scope.



INTRODUCTION

Transition-metal-catalyzed hydroarylation of olefins by aryl C−H bond activation has been identified as a powerful tool for alkylarene syntheses.[1] It has attracted considerable attention due to its excellent step- and atom-economy,[2] predictable regiocontrol, as well as oxidant-free and environmentally benign reaction conditions, as compared to traditional Friedel−Crafts reaction[3,1d] and catalytic conjugate addition of organometallic reagents to α,β-unsaturated carbonyl compounds.[4] Since Lewis and Smith[5] as well as Murai[6] showed the power of ruthenium(0) catalysts for chelation-assisted C−H/olefin addition, various catalysts based on ruthenium(II),[7] rhodium,[8] cobalt,[9,1c] or other metals[10] have been utilized in this field. Despite these remarkable advances, the user-friendly rhodium-(III)-catalyzed[11,1b] addition of aryl C−H bonds to these olefins, which bear functional groups, such as aldehyde, ketones, and esters, remained challenging. Sporadic early findings were mostly restricted to the assistance of relatively strong σ-directing groups, including pyri(mi)dines or pyrazoles, as reported by Li,[12] Huang,[13] Loh,[14] and Ellman.[15] Importantly, notable progress in rhodium(III)-catalyzed vinyl C−H bond addition to alkyl/aryl vinyl ketones was very recently made by Loh and co-workers,[16] while the acrolein and heteroaryl vinyl ketones delivered the adducts in rather low yields. Interestingly, α,β-unsaturated aldehydes were successfully utilized for the synthesis of azepinones through rhodium(III)-catalyzed cyclization with amides, as developed by Glorius and co-workers.[17]

Several cases of alkylations with allylic alcohols[18] and cyclopropanols[19] via rhodium(III)-catalyzed C−H activation provided the β-aryl ketone products. However, all of these protocols thus far required the use of $Cu(OAc)_2$ as the external oxidants, thereby generating unwanted stoichiometric metal-containing byproducts. Given these findings, along with our previous studies,[7b] we became intrigued by developing an environmentally benign C−H alkylation by synthetically useful coordinating group assistance. Thus, we herein report a mild rhodium(III)-catalyzed C−H activation with aryl oximes, pyri(mi)dine, and pyrazoles, occurring with a subsequent conjugate addition onto α,β-unsaturated carbonyl compounds to the deliver β-aryl aldehydes and ketones in an atom-economical fashion (Figure 1).

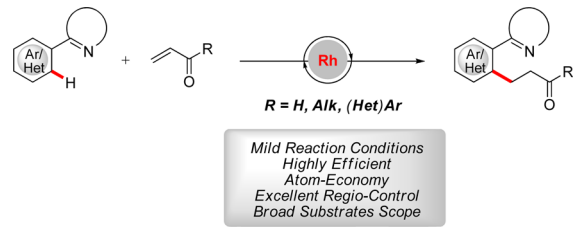


Figure 1. Rhodium(III)-catalyzed β-aryl aldehydes/ketones synthesis.

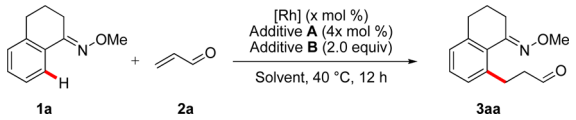
RESULTS AND DISCUSSION

With this in mind, we initiated our studies by testing different reaction conditions for the desired rhodium(III)-catalyzed C−H alkylation of ketoxime **1a** with acrolein (**2a**) to the synthesis of β-aryl propanal **3aa** (Table 1). Preliminary experiments demonstrated $[Cp^*Rh(MeCN)_3(SbF_6)_2]$ and pivalic acid (PivOH) as suitable catalytic systems, along with 1,4-dioxane as the reaction medium (70 °C), and the desired product **3aa** was obtained in modest yields (Table 1, entry 1). However, we were delighted to observe that the yield of **3aa** was significantly improved when setting the reaction temperature as low as 40 °C (Table 1, entries 1−3). A slightly reduced yield was obtained when employing $[Cp^*Rh(MeCN)_3(BF_4)_2]$ as the metal source (Table 1, entry 4). It is worth noting that the efficacy of catalysis was improved when using KOPiv as the

Received: November 4, 2016
Published: December 2, 2016

DOI: 10.1021/acs.joc.6b02672
J. Org. Chem. 2017, 82, 664−672

Table 1. Optimization of Rhodium(III)-Catalyzed C−H Functionalization with Ketoxime 1a[a]



entry	[Rh]/additive **A**	additive **B**	solvent	yield (%)[b]
1	$Cp^*Rh(MeCN)_3(SbF_6)_2$	PivOH	dioxane	48[c]
2	$Cp^*Rh(MeCN)_3(SbF_6)_2$	PivOH	dioxane	61[d]
3	$Cp^*Rh(MeCN)_3(SbF_6)_2$	PivOH	dioxane	81[e]
4	$Cp^*Rh(MeCN)_3(BF_4)_2$	PivOH	dioxane	73
5	$Cp^*Rh(MeCN)_3(SbF_6)_2$	KOPiv	TFE	86
6	**$[Cp^*RhCl_2]_2$/$AgSbF_6$**	**KOPiv**	**TFE**	**94**
7	−/$AgSbF_6$	KOPiv	TFE	0
8	$[Cp^*RhCl_2]_2$/−	KOPiv	TFE	68
9	$[Cp^*RhCl_2]_2$/$AgSbF_6$		TFE	36

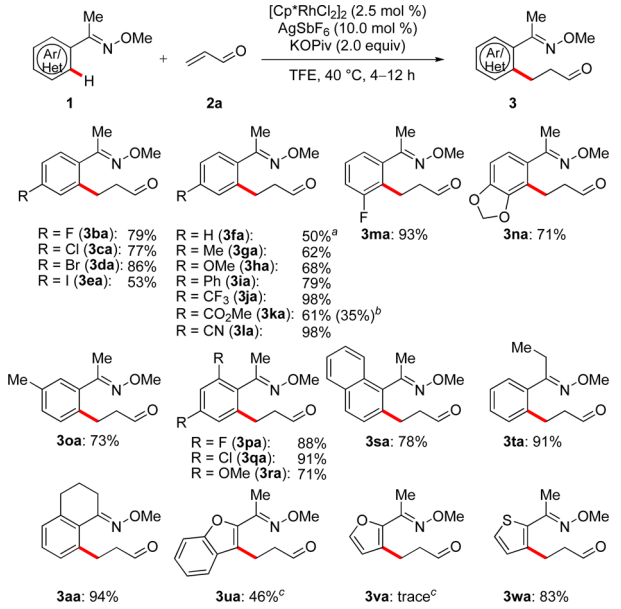
[a]General reaction conditions: **1a** (0.25 mmol), **2a** (0.50 mmol), $[Cp^*RhCl_2]_2$ (2.5 mol %), $AgSbF_6$ (10.0 mol %), KOPiv (0.50 mmol, 2.0 equiv), anhydrous TFE (1.0 mL), under Ar, 40 °C, 12 h. [b]Isolated yield. [c]At 70 °C. [d]At 60 °C. [e]At 40 °C (TFE = trifluoroethanol).

carboxylate salt in TFE as the solvent, with a yield of 86% (Table 1, entry 5). Subsequently, the combination of $[Cp^*RhCl_2]_2$ (2.5 mol %) and $AgSbF_6$ (10.0 mol %) proved to be the optimal metal catalyst of choice, delivering the desired product in excellent yield, up to 94% (Table 1, entry 6). Moreover, omission of either of the catalyst's components resulted in complete inhibition of the reaction or significantly reduced yield, which illustrated the importance of carboxylate assistance (Table 1, entries 7−9).[20]

Thereafter, the versatility of the optimized rhodium(III) catalyst was probed in the *ortho*-C−H alkylation with aryl ketoximes **1** and acrolein **2a**. We were pleased to find that valuable electrophilic functional groups, such as fluoro, chloro, bromo, or iodo substituents **1b−1e**, were well-tolerated under the standard reaction conditions (Scheme 1). Electron-neutral and electron-rich acetophenone oxime ethers **1f−1i** were also identified as viable substrates, furnishing the desired products in good yields. Excellent efficacy was also observed when utilizing electron-deficient substrates **1j−1l** with CF_3, CO_2Me, and CN, and the desired products were obtained in high yields, up to 98%. Intramolecular competition experiment with substrates bearing a *meta*-methyl substituent was largely governed by steric interactions to deliver the product **3oa** at the less sterically hindered position. However, the *meta*-substituted oximes **1m** and **1n** exhibited a strong secondary directing group effect,[21] thus leading to a site-selective formation of sterically more hindered compounds **3ma** and **3na** as the sole products. Remarkablely, more sterically hindered substrates **1p−1q** bearing 2,4-disubstituents and **1s** delivered the desired products in high yields, as also observed when utilizing substrate **1t** with an ethyl group in the oxime moiety. The versatile rhodium catalyst was not limited to alkylation on the arenes. Indeed, the direct C−H functionalization of thiophene (**1w**) occurred with high efficacy, while the benzofuran led to rather modest yield of the alkylated products **3ua**.

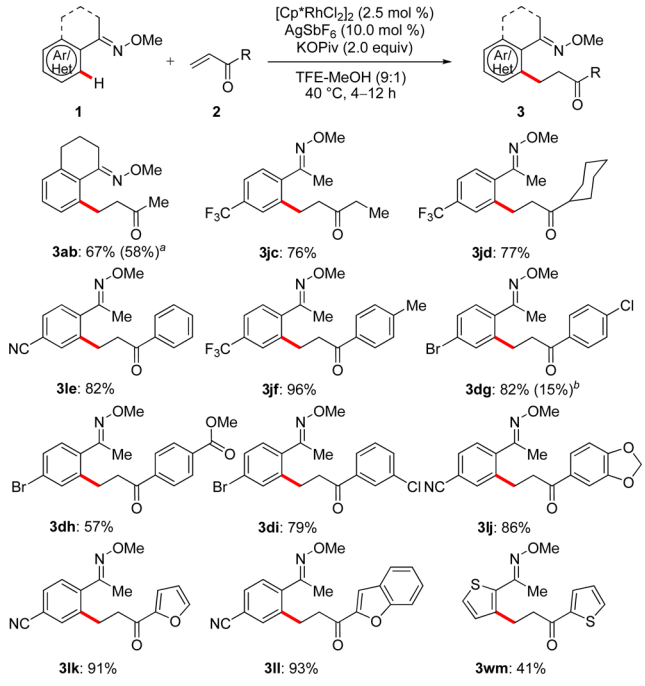
For the nature of the other α,β-unsaturated acceptors, the broadly applicable rhodium(III) catalyst enabled the efficient transformation of various alkyl/aryl vinyl ketones (Scheme 2). The reactivities of aliphatic enones **2b−2d** were very similar to that of the acrolein when employing 10% of MeOH as the cosolvent, yielding the corresponding β-aryl ketones (**3ab**, **3jc−3jd**) in good yields, which was likely attributed to the improved solubility of the carboxylates. Beyond that, among a set of aryl vinyl ketones, different substitutions were observed to be viable under optimal conditions, while intermolecular oxa-Michael

Scheme 1. Substrate Scope of Rhodium(III)-Catalyzed C−H Alkylation with Acrolein 2a*



*Reaction conditions: $[Cp^*RhCl_2]_2$ (2.5 mol %), $AgSbF_6$ (10.0 mol %), KOPiv (2.0 equiv), **1** (0.25 mmol), **2a** (0.50 mmol) in TFE (1.0 mL) for 4−12 h. [a]0.5 mmol scale. [b]Yield for the dialkylated product. [c]The reaction was performed at 60 °C for 12 h.

Scheme 2. Rhodium(III)-Catalyzed Conjugate Addition of Aryl C−H Bonds to α,β-Unsaturated Ketones 2*



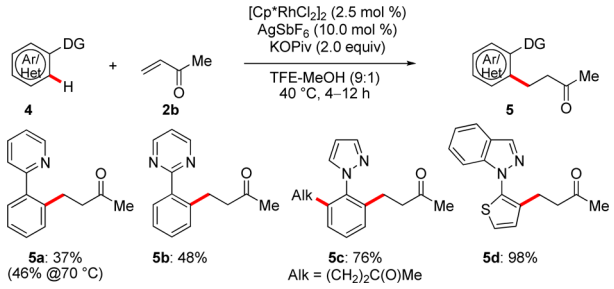
*Reaction conditions: $[Cp^*RhCl_2]_2$ (2.5 mol %), $AgSbF_6$ (10.0 mol %), KOPiv (2.0 equiv), **1** (0.25 mmol), **2** (0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 4−12 h. [a]TFE (1.0 mL) as the solvent. [b]Yield for the dialkylated product.

DOI: 10.1021/acs.joc.6b02672
J. Org. Chem. 2017, 82, 664−672

additions[22] of alcohols to enones and self-condensation of aryl vinyl ketone[7g,23] did not occur. A variety of *para*- and *meta*-substituted aryl enones bearing electron-donating or electron-withdrawing groups could be transformed into the alkylated products **3le**−**3lj** with remarkably high efficacy. It is worth noting that the heteroaryl vinyl ketones, such as furan, benzofuran, and thiophene, were successfully employed, as well, furnishing the desired products **3lk** and **3ll**, respectively, in excellent isolated yields, whereas product **3wm** was obtained in modest yield.

Moreover, a variation of the relatively strong σ-directing groups, such as pyridine, pyrimidine, and pyrazoles, was subsequently proven to be suitable substrates. **4a** and **4b** delivered the site-selectively monoalkylated products, although **5a** and **5b** were generated in modest yields. Importantly, dialkylated product **5c** was generated in high yield with pyrazole assistance. To our delight, the rhodium(III) catalyst also exhibited high efficacy for the C−H alkylation of 1-(thiophen-2-yl)-1*H*-indazole **4d** (Scheme 3).

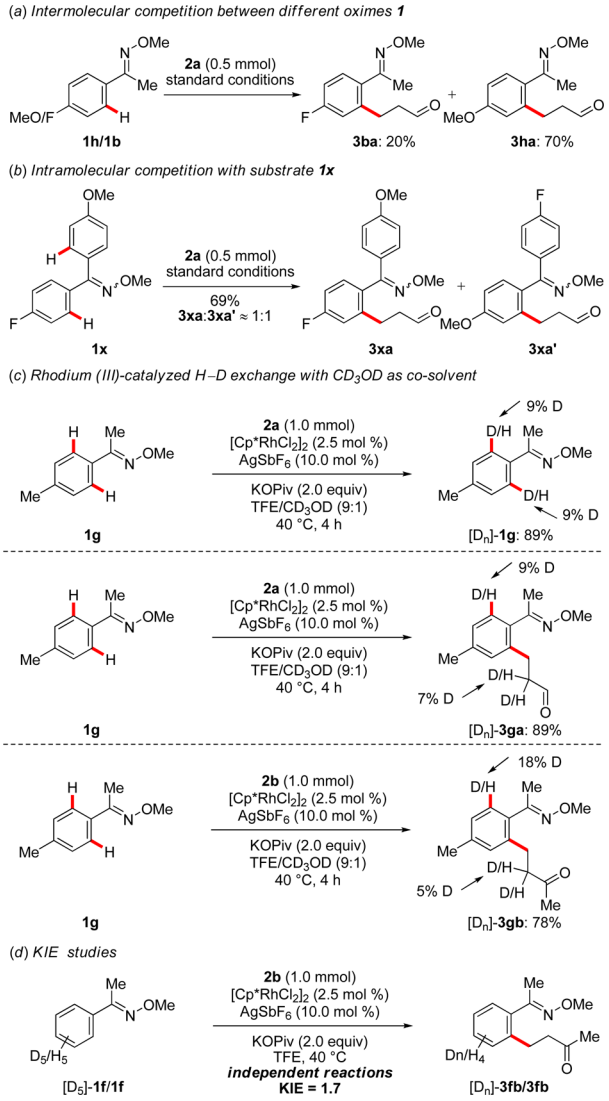
Scheme 3. Rhodium(III)-Catalyzed C−H Activation by σ-Directing Group Assistance



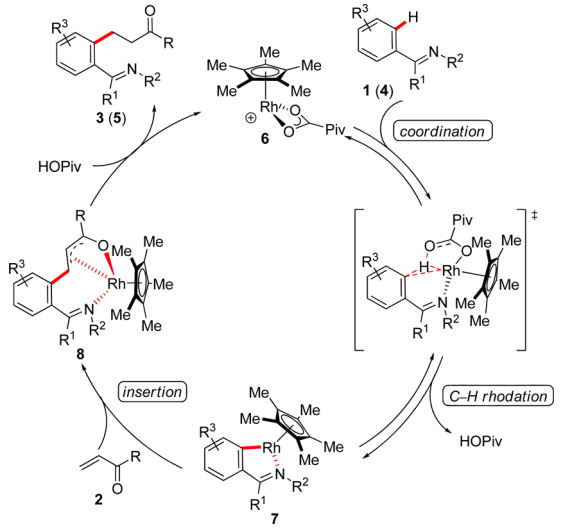
Mechanistic studies toward rhodium(III)-catalyzed C−H functionalization of aryl oxime **1** have been performed (Scheme 4). Intermolecular competition experiment between differently substituted **1** highlighted that electron-rich aryl oxime **1h** was preferentially converted compared to electron-deficient **1b** (Scheme 4a). In contrast, an intramolecular competition reaction with substrate **1x** showed that the electronic nature of the substituent exerts only a minor influence on the reactivity (Scheme 4b). These results may suggest the in situ generated cationic rhodium(III) complex operating by a base-assisted electrophilic-type activation mode.[24] Furthermore, we explored the catalytic C−H bond functionalization on aryl oxime **1g** in the presence of isotopically labeled methanol as the cosolvent. A significant H/D exchange in the *ortho*-position of both the reisolated starting material [D$_n$]-**1g** and products [D$_n$]-**3ga** and [D$_n$]-**3gb** was observed. Beyond that, H/D exchange was also achieved at the α-position of the β-aryl aldehyde/ketone, where CD_3OD provides D to lead to a proto-demetalation step to yield product **3** (Scheme 4c). Moreover, the rhodium-catalyzed C−H alkylation with isotopically labeled substrates indicated a negligible kinetic isotope effect (KIE) of $k_H/k_D \approx 1.7$ for the intermolecular KIE (Scheme 4d). This result indicated that the C−H bond metalation is likely not the rate-determining step.

On the basis of our mechanistic studies and previous reports,[7b,12−15] a plausible catalytic cycle is proposed in Scheme 5, which commences with an irreversible C−H activation on arenes **1** and **4**, yielding the cyclometalated complex **7** by carboxylate assistance, subsequent migratory insertion of α,β-unsaturated acceptors **2**, and proto-demetalation to deliver the desired products **3** and **5**.

Scheme 4. Mechanistic Studies



Scheme 5. Proposed Catalytic Cycle



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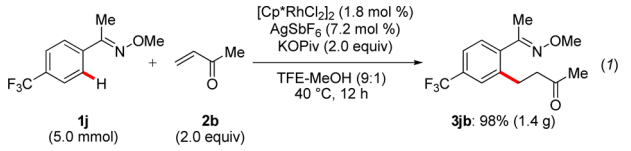
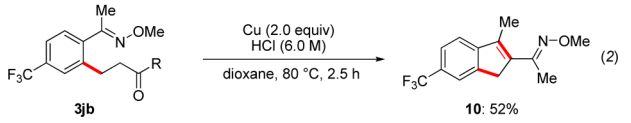
Furthermore, the outstanding catalytic efficacy and robustness of the rhodium(III) catalysis were reflected by a 5 mmol scale reaction performed with a catalyst loading as low as 1.8 mol %, furnishing the desired β-aryl ketone **3jb** in 98% yield (eq 1). In addition, to illustrate the synthetic utility of the





products synthesized by our method, a derivatization reaction was performed with compound **3jb** (eq 2). Thus, the copper-mediated indene synthesis proved viable, delivering product **10** in 52% yield.[19,25]

CONCLUSION

In summary, we have developed a highly efficient and straightforward route to access β-aryl ketones through rhodium(III)-catalyzed C−H hydroarylation of conjugated alkenes **2**. Thus, notable features of our strategy include ample substrate scope, excellent regioselectivity, remarkable functional group tolerance, as well as mild reaction. Furthermore, the versatile rhodium catalysis allowed for alkylations of (hetero)aryl oximes, pyri(mi)dine, and pyrazoles. Mechanistic studies provided strong support for a reversible C−H bond activation and suggested the proto-demetalation to be the rate-determining step.

EXPERIMENTAL SECTION

General Procedure and Characterization Data for the Synthesis of 3 and 5. A suspension of ketoxime **1** or **4** (0.25 mmol, 1.00 equiv), acrolein, or α,β-unsaturated ketone **2** (0.50 mmol, 2.00 equiv), $[Cp^*RhCl_2]_2$ (3.8 mg, 2.5 mol %), $AgSbF_6$ (8.6 mg, 10.0 mol %), and KOPiv (70.0 mg, 2.0 equiv) in anhydrous TFE (1.0 mL) was stirred at 40 °C for 4−12 h under an atmosphere of Ar. At ambient temperature, the solvent was evaporated in vacuo, and the remaining residue was purified by column chromatography on silica gel (*n*-hexane/EtOAc) to yield products **3** and **5**.

3-{5-Fluoro-2-[1-(methoxyimino)ethyl]phenyl}propanal (3ba). The general procedure was followed using **1b** (42.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3ba** (44 mg, 79%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (s, 1H), 7.25−7.18 (m, 1H), 6.93 (ddd, J = 7.1, 5.5, 2.7 Hz, 2H), 3.93 (s, 3H), 3.01 (t, J = 7.6 Hz, 2H), 2.81 (t, J = 7.6 Hz, 2H), 2.17 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.0, 162.5 (d, J_{C-F} = 248.0 Hz), 155.3, 141.2 (d, J_{C-F} = 7.5 Hz), 133.2 (d, J_{C-F} = 3.2 Hz), 130.4 (d, J_{C-F} = 8.5 Hz), 116.6 (d, J_{C-F} = 21.4 Hz), 113.5 (d, J_{C-F} = 21.4 Hz), 61.8, 45.5, 26.1, 16.5; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −112.94 (d, J = 4.3 Hz); IR (ATR) 2936, 1724, 1606, 1497, 1228, 1042, 878, 750, 571 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{15}FNO_2$ 224.1087, found 224.1093 [M + H$^+$].

3-{5-Chloro-2-[1-(methoxyimino)ethyl]phenyl}propanal (3ca). The general procedure was followed using **1c** (46.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3ca** (46 mg, 77%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (s, 1H), 7.25−7.15 (m, 3H), 3.93 (s, 3H), 3.00 (t, J = 7.2 Hz, 2H), 2.83−2.78 (m, 2H), 2.17 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.9, 155.1, 140.5, 135.6, 134.4, 130.0, 129.9, 126.7, 61.9, 45.6, 26.0, 16.3; IR (ATR) 2933, 1722, 1592, 1485, 1103, 1042, 886, 817, 750, 557 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{15}ClNO_2$ 240.0791, found 240.0799 [M + H$^+$].

3-{5-Bromo-2-[1-(methoxyimino)ethyl]phenyl}propanal (3da). The general procedure was followed using **1d** (57.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3da** (61 mg, 86%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.80 (t, J = 0.9 Hz, 1H), 7.41−7.34 (m, 2H), 7.11 (d, J = 8.1 Hz, 1H), 3.93 (s, 3H), 2.99 (t, J = 7.5 Hz, 2H), 2.80 (t, J = 7.5 Hz, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.0, 155.1, 140.8, 136.1, 132.9, 130.2, 129.6, 122.6, 61.9, 45.6, 25.9, 16.2; IR (ATR) 2934, 1721, 1586, 1497, 1364, 1312, 1041, 883, 816, 750, 554 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{15}BrNO_2$ 284.0286, found 284.0293 [M + H$^+$].

3-{5-Iodo-2-[1-(methoxyimino)ethyl]phenyl}propanal (3ea). The general procedure was followed using **1e** (69.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3ea** (44 mg, 53%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.80 (s, 1H), 7.65−7.53 (m, 2H), 6.95 (d, J = 7.9 Hz, 1H), 3.93 (s, 3H), 2.96 (t, J = 7.6 Hz, 2H), 2.80 (t, J = 7.6 Hz, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.0, 155.2, 140.9, 138.8, 136.7, 135.6, 130.3, 94.5, 61.9, 45.7, 25.8, 16.2; IR (ATR) 2931, 1720, 1581, 1497, 1364, 1041, 883, 816, 750, 538 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{15}INO_2$ 332.0147, found 332.0152 [M + H$^+$].

3-{2-[1-(Methoxyimino)ethyl]phenyl]propanal (3fa). The general procedure was followed using **1f** (75.0 mg, 0.50 mmol) and **2a** (56.0 mg, 1.00 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 15:1) yielded **3fa** (51 mg, 50%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.80 (s, 1H), 7.34−7.16 (m, 4H), 3.94 (s, 3H), 3.02 (dd, J = 9.7, 5.7 Hz, 2H), 2.83−2.76 (m, 2H), 2.19 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.6, 156.1, 138.4, 137.1, 129.9, 128.7, 128.6, 126.5, 61.8, 45.9, 26.1, 16.4; IR (ATR) 2919, 2719, 1721, 1490, 1275, 1045, 959, 869, 751 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{16}NO_2$ 206.1181, found 206.1185 [M + H$^+$].

3-{2-[1-(Methoxyimino)ethyl]-5-methylphenyl}propanal (3ga). The general procedure was followed using **1g** (41.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ga** (34 mg, 62%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (t, J = 1.2 Hz, 1H), 7.33−6.90 (m, 3H), 3.93 (s, 3H), 3.04−2.95 (m, 2H), 2.84−2.75 (m, 2H), 2.32 (s, 3H), 2.17 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.8, 156.0, 138.5, 138.2, 134.2, 130.7, 128.6, 127.2, 61.7, 46.0, 26.2, 21.2, 16.4; IR (ATR) 2935, 1722, 1613, 1445, 1364, 1312, 1135, 1042, 878, 818, 750, 669 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{18}NO_2$ 220.1338, found 220.1345 [M + H$^+$].

3-{5-Methoxy-2-[1-(methoxyimino)ethyl]phenyl}propanal (3ha). The general procedure was followed using **1h** (45.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.25 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ha** (40 mg, 68%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.8, 7.18 (d, J = 8.2 Hz, 1H), 6.77 (dd, J = 8.2, 2.5 Hz, 1H), 6.75 (d, J = 2.5 Hz, 1H), 3.92 (s, 3H), 3.80 (s, 3H), 3.01 (t, J = 7.6 Hz, 2H), 2.80 (t, J = 7.6 Hz, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.6, 159.6, 155.8, 140.2, 130.0, 129.6, 115.6, 111.8, 61.7, 55.3, 45.9, 26.5, 16.4; IR (ATR) 2922, 1717, 1606, 1444, 1242, 1042, 869, 590 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{18}NO_3$ 236.1287, found 236.1292 [M + H$^+$].

3-{4-[1-(Methoxyimino)ethyl]biphenyl-3-yl}propanal (3ia). The general procedure was followed using **1i** (56.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3ia** (55 mg, 79%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.83 (s, 1H), 7.59−7.54 (m, 2H), 7.49−7.40 (m, 4H), 7.38−7.29 (m, 2H), 3.95 (s, 3H), 3.10 (dd, J = 9.8, 5.5 Hz, 2H), 2.85 (dd, J = 9.8, 5.5 Hz, 2H), 2.22 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.6, 155.8, 141.6, 140.5, 139.0, 136.0, 129.1, 128.9, 127.1, 125.3, 127.6, 61.8, 46.0, 29.7, 26.4, 16.4; IR (ATR) 2934, 2723, 1720, 1586, 1485, 1362, 1042, 888, 763, 697 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{18}H_{19}NO_2$ 281.1416, found 281.1423 [M + H$^+$].

DOI: 10.1021/acs.joc.6b02672
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3-{2-[1-(Methoxyimino)ethyl]-5-[trifluoromethyl]phenyl}propanal (3ja). The general procedure was followed using **1j** (55.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ja** (67 mg, 98%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.82 (s, 1H), 7.50 (d, J = 8.5 Hz, 1H), 7.49 (s, 1H), 7.36 (d, J = 8.5 Hz, 1H), 3.95 (s, 3H), 3.07 (dd, J = 9.9, 5.5 Hz, 2H), 2.84 (dd, J = 9.9, 5.5 Hz, 2H), 2.20 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.7, 154.9, 140.6, 139.5, 130.7 (q, J_{C-F} = 32.5 Hz), 129.1, 126.8 (q, J_{C-F} = 3.8 Hz),123.9 (q, J_{C-F} = 273.6 Hz), 123.4 (q, J_{C-F} = 3.8 Hz), 62.0, 45.6, 26.0, 16.2; IR (ATR) 2939, 1725, 1414, 1331, 1163, 1120, 1043, 897, 832, 748, 659 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{15}F_3NO_2$ 274.1055, found 274.1059 [M + H$^+$].

Methyl 4-[1-(Methoxyimino)ethyl]-3-(3-oxopropyl)benzoate (3ka). The general procedure was followed using **1k** (52.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1 → 5:1) yielded **3ka** (40 mg, 61%) and **3ka′** (28 mg, 35%) as colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.82 (s, 1H), 8.06−7.80 (m, 2H), 7.41−7.19 (m, 1H), 3.95 (s, 3H), 3.92 (s, 3H), 3.07 (dd, J = 9.9, 5.6 Hz, 2H), 2.84 (dd, J = 9.9, 5.6 Hz, 2H), 2.20 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.1, 166.6, 155.3, 141.5, 138.8, 131.0, 130.1, 128.8, 127.6, 62.0, 52.2, 45.7, 26.0, 16.2; IR (ATR) 2938, 1718, 1436, 1293, 1196, 1113, 1042, 882, 816, 769 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{18}NO_4$ 264.1236, found 264.1239 [M + H$^+$]. **Methyl 4-[1-(methoxyimino)ethyl]-3,5-bis(3-oxopropyl)benzoate (3ka′)**: colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (s, 2H), 7.77 (s, 2H), 3.93 (s, 3H), 3.91 (s, 3H), 2.95−2.70 (m, 8H), 2.15 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.8, 166.5, 155.0, 141.4, 139.3, 130.4, 128.3, 61.9, 52.3, 45.2, 25.6, 17.0; IR (ATR) 2951, 1716, 1435, 1215, 1122, 1039, 876, 769 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{17}H_{22}NO_5$ 320.1498, found 320.1490 [M + H$^+$].

4-[1-(Methoxyimino)ethyl]-3-(3-oxopropyl)benzonitrile (3la). The general procedure was followed using **1l** (44.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3la** (66 mg, 98%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.82 (s, 1H), 7.56 (d, J = 2.3 Hz, 1H), 7.54 (dd, J = 7.8, 2.3 Hz, 1H), 7.36 (d, J = 7.8 Hz, 1H), 3.96 (s, 3H), 3.06 (dd, J = 9.7, 5.4 Hz, 2H), 2.84 (dd, J = 9.7, 5.4 Hz, 2H), 2.20 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.5, 154.6, 141.6, 140.1, 133.6, 130.1, 129.4, 118.4, 112.3, 62.0, 45.2, 25.7, 16.0; IR (ATR) 2937, 2230, 1721, 1042, 884, 832, 749 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{15}N_2O_2$ 231.1134, found 231.1139 [M + H$^+$].

3-{2-Fluoro-6-[1-(methoxyimino)ethyl]phenyl}propanal (3ma). The general procedure was followed using **1m** (47.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ma** (52 mg, 93%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (t, J = 1.2 Hz, 1H), 7.33−6.91 (m, 3H), 3.94 (s, 3H), 3.14−2.92 (m, 2H), 2.88−2.70 (m, 2H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.4, 161.5 (d, J_{C-F} = 245.1 Hz), 154.9 (d, J_{C-F} = 2.7 Hz), 139.3 (d, J_{C-F} = 4.5 Hz), 127.7 (d, J_{C-F} = 9.2 Hz), 126.0 (d, J_{C-F} = 16.2 Hz), 124.2 (d, J_{C-F} = 3.2 Hz), 115.4 (d, J_{C-F} = 23.0 Hz), 61.9, 44.6, 19.4 (d, J_{C-F} = 3.8 Hz), 16.4; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −116.36 (s); IR (ATR) 2936, 1720, 1573, 1453, 1319, 1240, 1137, 1043, 865, 790, 747 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{15}FNO_2$ 224.1087, found 224.1091 [M + H$^+$].

3-{5-[1-(Methoxyimino)ethyl]benzo[*d*][1,3]dioxol-4-yl}propanal (3na). The general procedure was followed using **1n** (48.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3na** (48 mg, 77%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (t, J = 1.3 Hz, 1H), 6.78 (d, J = 8.1 Hz, 1H), 6.71 (d, J = 8.1 Hz, 1H), 5.96 (s, 2H), 3.91 (s, 3H), 3.05−2.95 (m, 2H), 2.83−2.75 (m, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.9, 155.3, 147.0, 146.5, 131.3, 122.3, 120.5, 106.6, 101.1, 61.8, 43.9, 20.2, 16.4; IR (ATR) 2897, 2817, 2721, 1720, 1450, 1307, 1249, 1039, 868, 804, 750, 635, 551 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{16}NO_4$ 250.1079, found 250.1082 [M + H$^+$].

3-{2-[1-(Methoxyimino)ethyl]-4-methylphenyl}propanal (3oa). The general procedure was followed using **1o** (41.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3oa** (40 mg, 73%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.80 (t, J = 1.2 Hz, 1H), 7.31−6.90 (m, 3H), 3.93 (s, 3H), 2.97 (t, J = 7.7 Hz, 2H), 2.84−2.73 (m, 2H), 2.33 (d, J = 6.7 Hz, 3H), 2.17 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.8, 156.3, 137.0, 136.1, 135.2, 129.8, 129.4, 129.2, 61.8, 46.0, 25.7, 20.9, 16.5; IR (ATR) 2925, 1722, 1500, 1457, 1364, 1318, 1179, 1044, 865, 750, 653 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{13}H_{18}NO_2$ 220.1339, found 220.1342 [M + H$^+$].

3-{3,5-Difluoro-2-[1-(methoxyimino)ethyl]phenyl}propanal (3pa). The general procedure was followed using **1p** (47.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3pa** (53 mg, 88%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.79 (s, 1H), 6.88−6.60 (m, 2H), 3.94 (s, 3H), 2.94 (dd, J = 9.4, 5.6 Hz, 2H), 2.80 (dd, J = 7.8, 7.2 Hz, 2H), 2.14 (d, J = 1.4 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.5, 162.5 (dd, J_{C-F} = 250.0 Hz, J_{C-F} = 13.4 Hz), 161.0 (dd, J_{C-F} = 249.0 Hz, J_{C-F} = 13.0 Hz), 151.3, 142.9 (dd, J_{C-F} = 9.0 Hz, J_{C-F} = 4.4 Hz), 121.6 (dd, J_{C-F} = 15.9 Hz, J_{C-F} = 3.8 Hz), 112.1 (dd, J_{C-F} = 21.3 Hz, J_{C-F} = 3.3 Hz), 102.2 (t, J_{C-F} = 25.8 Hz), 61.9, 45.4, 25.6 (d, J_{C-F} = 2.3 Hz), 16.6 (d, J_{C-F} = 2.6 Hz); ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −109.4 (d, J_{C-F} = 8.1 Hz), −110.5 (d, J_{C-F} = 8.1 Hz); IR (ATR) 2940, 1724, 1590, 1429, 1321, 1121, 1042, 884, 763, 572 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{14}F_2NO_2$ 242.0993, found 242.0996 [M + H$^+$].

3-{3,5-Dichloro-2-[1-(methoxyimino)ethyl]phenyl}propanal (3qa). The general procedure was followed using **1q** (52.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3qa** (62 mg, 91%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.79 (s, 1H), 7.30 (d, J = 1.9 Hz, 1H), 7.15 (d, J = 1.9 Hz, 1H), 3.95 (s, 3H), 2.83 (dd, J = 12.8, 5.6 Hz, 4H), 2.14 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 200.2, 153.7, 142.4, 134.7, 134.4, 128.0, 127.6, 62.0, 45.3, 29.7, 25.9, 16.4; IR (ATR) 2937, 2818, 1722, 1584, 1460, 1364, 1304, 1115, 1044, 885, 825, 750, 580 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{12}H_{14}Cl_2NO_2$ 274.0402, found 274.0407 [M + H$^+$].

3-{3,5-Dimethoxy-2-[1-(methoxyimino)ethyl]phenyl}propanal (3ra). The general procedure was followed using **1r** (53.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ra** (47 mg, 71%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.79 (s, 1H), 6.35 (d, J = 2.4 Hz, 1H), 6.33 (d, J = 2.4 Hz, 1H), 3.92 (s, 3H), 3.79 (s, 3H), 3.77 (s, 3H), 2.89−2.83 (m, 2H), 2.82−2.75 (m, 2H), 2.08 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.6, 160.7, 158.9, 154.8, 140.9, 119.3, 105.6, 96.7, 61.6, 55.6, 55.4, 46.1, 26.1, 16.8; IR (ATR) 2936, 1719, 1602, 1456, 1319, 1201, 1155, 1041, 872, 750, 669, 582 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{20}NO_4$ 266.1392, found 266.1396 [M + H$^+$].

3-{1-[1-(Methoxyimino)ethyl]naphthalen-2-yl}propanal (3sa). The general procedure was followed using **1s** (50.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3sa** (50 mg, 78%) as a slight yellow oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.83 (s, 1H), 7.81 (d, J = 8.3 Hz, 1H), 7.78 (d, J = 8.5 Hz, 1H), 7.70 (d, J = 8.3 Hz, 1H), 7.52−7.41 (m, 2H), 7.33 (d, J = 8.5 Hz, 1H), 4.00 (s, 3H), 3.20−2.72 (m, 4H), 2.27 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.3, 155.7, 135.8, 133.6, 132.4, 131.8, 128.9, 128.2, 127.2, 126.7, 125.6, 124.9, 61.9, 46.0, 26.2, 17.6; IR (ATR) 2920, 1721, 1508, 1427, 1363, 1275, 1045, 878, 818, 750 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{16}H_{18}NO_2$ 256.1338, found 256.1342 [M + H$^+$].

3-{2-[1-(Methoxyimino)propyl]phenyl}propanal (3ta). The general procedure was followed using **1t** (41.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ta** (50 mg, 91%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.32−7.14 (m, 4H), 3.91 (s, 3H), 2.94−2.84 (m, 2H), 2.82−2.76 (m, 2H), 2.67 (q, J = 7.6 Hz, 2H), 2.13 (s, 3H), 1.01 (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 207.9, 161.4, 139.4, 135.9, 129.7, 128.7, 128.6,

DOI: 10.1021/acs.joc.6b02672
J. Org. Chem. 2017, 82, 664−672

126.2, 61.7, 45.8, 29.9, 27.6, 23.2, 10.2; IR (ATR) 2919, 2719, 1721, 1490, 1275, 1045, 959, 869, 751 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{13}H_{18}NO_2$ 220.1338, found 220.1343 [M + H^+].

3-{8-(Methoxyimino)-5,6,7,8-tetrahydronaphthalen-1-yl}propanal (3aa). The general procedure was followed using **1a** (44.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 15:1) yielded **3aa** (54 mg, 94%) as a colorless solid: mp = 33−35 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.84 (t, *J* = 1.6 Hz, 1H), 7.16 (dd, *J* = 7.5, 7.3 Hz, 1H), 7.10 (dd, *J* = 7.5, 1.3 Hz, 1H), 7.03 (dd, *J* = 7.3, 1.3 Hz, 1H), 3.93 (s, 3H), 3.28−3.22 (m, 2H), 2.84 (ddd, *J* = 7.4, 5.4, 1.6 Hz, 2H), 2.75 (t, *J* = 6.9 Hz, 2H), 2.69−2.63 (m, 2H), 1.80−1.70 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 202.6, 155.0, 142.2, 139.7, 129.6, 129.5, 128.3, 126.6, 62.0, 46.1, 31.2, 28.5, 25.5, 21.1; IR (ATR) 2921, 1714, 1457, 1276, 1134, 1049, 881, 750, 659 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{14}H_{18}NO_2$ 232.1338, found 232.1343 [M + H^+].

3-{2-[1-(Methoxyimino)ethyl]benzofuran-3-yl}propanal (3ua). The general procedure was followed using **1u** (48.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) at 60 °C for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ua** (28 mg, 46%) as a slight yellow oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.84 (t, *J* = 1.4 Hz, 1H), 7.55 (dd, *J* = 7.1, 6.2 Hz, 1H), 7.44 (d, *J* = 8.1 Hz, 1H), 7.33−7.28 (m, 1H), 7.27−7.22 (m, 1H), 3.99 (s, 3H), 3.30−3.20 (m, 2H), 2.82 (td, *J* = 7.6, 1.4 Hz, 2H), 2.28 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 202.0, 153.9, 149.5, 147.4, 129.3, 125.1, 122.9, 119.8, 117.4, 111.4, 62.4, 43.3, 17.2, 12.0; IR (ATR) 2934, 2818, 1721, 1454, 1368, 1264, 1133, 1045, 886, 745, 542 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{14}H_{15}NO_3$ 245.1052, found 245.1057 [M + H^+].

3-{2-[1-(Methoxyimino)ethyl]thiophen-3-yl}propanal (3wa). The general procedure was followed using **1w** (39.0 mg, 0.25 mmol) and **2a** (28.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3wa** (44 mg, 83%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.81 (t, *J* = 1.4 Hz, 1H), 7.22 (d, *J* = 5.1 Hz, 1H), 6.92 (d, *J* = 5.1 Hz, 1H), 3.94 (s, 3H), 3.16 (t, *J* = 7.5 Hz, 2H), 2.78 (td, *J* = 7.5, 1.4 Hz, 2H), 2.23 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 202.0, 150.6, 139.2, 134.4, 130.8, 124.8, 62.0, 44.4, 23.0, 15.7; IR (ATR) 2934, 2817, 2717, 1722, 1428, 1276, 1185, 1048, 879, 750, 656, 541 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{10}H_{13}NO_2S$ 211.0667, found 211.0671 [M + H^+].

4-[8-(Methoxyimino)-5,6,7,8-tetrahydronaphthalen-1-yl]butan-2-one (3ab). The general procedure was followed using **1a** (44.0 mg, 0.25 mmol) and **2b** (35.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ab** (41 mg, 67%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.14 (dd, *J* = 7.5, 7.3 Hz, 1H), 7.09 (dd, *J* = 7.5, 1.1 Hz, 1H), 7.01 (d, *J* = 7.3 Hz, 1H), 3.92 (s, 3H), 3.22−3.14 (m, 2H), 2.89−2.80 (m, 2H), 2.74 (t, *J* = 6.8 Hz, 2H), 2.68−2.62 (m, 2H), 2.15 (s, 3H), 1.80−1.70 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 208.8, 155.1, 142.1, 140.4, 129.6, 129.6, 128.2, 126.3, 61.9, 45.9, 31.2, 30.0, 29.9, 25.5, 21.2; IR (ATR) 2934, 1714, 1461, 1276, 1154, 1038, 889, 750, 544 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{15}H_{20}NO_2$ 246.1494, found 246.1497 [M + H^+].

1-{2-[1-(Methoxyimino)ethyl]-5-(trifluoromethyl)phenyl}pentan-3-one (3jc). The general procedure was followed using **1j** (55.0 mg, 0.25 mmol) and **2c** (42.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3jc** (57 mg, 76%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.50−7.45 (m, 2H), 7.38−7.30 (m, 1H), 3.95 (s, 3H), 3.07−2.95 (m, 2H), 2.82−2.70 (m, 2H), 2.42 (q, *J* = 7.3 Hz, 2H), 2.20 (s, 3H), 1.07 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 209.9, 155.2, 140.7, 140.3, 130.6 (q, J_{C-F} = 32.3 Hz), 129.0, 126.6 (q, J_{C-F} = 3.6 Hz), 123.9 (q, J_{C-F} = 272.4 Hz), 123.1 (q, J_{C-F} = 3.7 Hz), 61.9, 43.8, 36.0, 27.6, 16.2, 7.8; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −62.8 (s); IR (ATR) 2940, 1714, 1413, 1332, 1276, 1123, 1044, 887, 834, 750 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{15}H_{19}F_3NO_2$ 302.1368, found 302.1374 [M + H^+].

1-Cyclohexyl-3-{2-[1-(methoxyimino)ethyl]-5-(trifluoromethyl)phenyl}propan-1-one (3jd). The general procedure was followed using **1j** (55.0 mg, 0.25 mmol) and **2d** (69.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 30:1) yielded **3jd** (68 mg, 77%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.48 (d, *J* = 8.2 Hz, 1H), 7.47 (s, 1H), 7.33 (d, *J* = 8.2 Hz, 1H), 3.94 (s, 3H), 2.99−2.93 (m, 2H), 2.84−2.74 (m, 2H), 2.31 (ddd, *J* = 11.2, 7.3, 3.3 Hz, 1H), 2.19 (s, 3H), 1.91−1.73 (m, 4H), 1.47−1.11 (m, 5H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 212.5, 155.2, 140.7, 140.5, 130.6 (q, J_{C-F} = 32.3 Hz), 129.0, 126.6 (q, J_{C-F} = 3.7 Hz), 123.9 (q, J_{C-F} = 273.1 Hz), 123.1 (q, J_{C-F} = 3.6 Hz), 61.9, 50.9, 42.2, 28.5, 27.5, 25.8, 25.6, 16.3; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −62.7 (s); IR (ATR) 2931, 2855, 1706, 1449, 1369, 1276, 1122, 1044, 894, 832, 750 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{19}H_{25}F_3NO_2$ 356.1837, found 356.1841 [M + H^+].

4-[1-(Methoxyimino)ethyl]-3-(3-oxo-3-phenylpropyl)benzonitrile (3le). The general procedure was followed using **1l** (44.0 mg, 0.25 mmol) and **2e** (66 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 20:1) yielded **3le** (63 mg, 82%) as a colorless solid: mp = 92−93 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.98−7.93 (m, 2H), 7.61 (d, *J* = 1.4 Hz, 1H), 7.59−7.55 (m, 1H), 7.53 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.49−7.44 (m, 2H), 7.35 (d, *J* = 8.0 Hz, 1H), 3.90 (s, 3H), 3.39−3.30 (m, 2H), 3.18−3.13 (m, 1H), 2.21 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 198.4, 154.8, 141.8, 141.0, 136.7, 133.7, 133.3, 129.9, 129.4, 128.7, 128.0, 118.5, 112.4, 62.1, 40.2, 27.8, 16.2; IR (ATR) 2937, 2901, 1680, 1597, 1440, 1296, 1203, 1043, 887, 838, 740, 687, 564 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{19}H_{19}N_2O_2$ 307.1447, found 307.1449 [M + H^+].

3-{2-[1-(Methoxyimino)ethyl]-5-(trifluoromethyl)phenyl}-1-*p*-tolylpropan-1-one (3jf). The general procedure was followed using **1j** (55.0 mg, 0.25 mmol) and **2f** (73.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 30:1) yielded **3jf** (87 mg, 96%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.86 (d, *J* = 8.2 Hz, 2H), 7.55 (s, 1H), 7.50 (d, *J* = 8.1 Hz, 1H), 7.36 (d, *J* = 8.1 Hz, 1H), 7.25 (d, *J* = 8.2 Hz, 2H), 3.90 (s, 3H), 3.36−3.28 (m, 2H), 3.20−3.11 (m, 2H), 2.40 (s, 3H), 2.21 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 198.4, 155.2, 144.0, 140.8, 140.5, 134.3, 130.7 (q, J_{C-F} = 32.4 Hz), 129.3, 129.1, 128.2, 126.9 (q, J_{C-F} = 3.7 Hz), 124.0 (q, J_{C-F} = 272.3 Hz), 123.2 (q, J_{C-F} = 3.7 Hz), 61.9, 40.5, 28.2, 21.6, 16.3; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −62.68 (s); IR (ATR) 2938, 1681, 1607, 1586, 1446, 1364, 1332, 1125, 1044, 910, 833, 750 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{20}H_{21}F_3NO_2$ 364.1524, found 364.1528 [M + H^+].

3-{5-Bromo-2-[1-(methoxyimino)ethyl]phenyl}-1-(4-chlorophenyl)propan-1-one (3dg). The general procedure was followed using **1d** (57.0 mg, 0.25 mmol) and **2g** (83.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3dg** (81 mg, 82%) and **3dg′** (21 mg, 15%) as colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.89 (d, *J* = 8.5 Hz, 2H), 7.43 (s, 1H), 7.42 (d, *J* = 8.5 Hz, 2H), 7.37 (dd, *J* = 8.2, 2.0 Hz, 1H), 7.12 (d, *J* = 8.2 Hz, 1H), 3.87 (s, 3H), 3.32−3.26 (m, 2H), 3.09−3.04 (m, 2H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 197.6, 155.4, 141.4, 139.6, 136.2, 135.1, 133.0, 130.2, 129.6, 129.4, 129.0, 122.6, 61.9, 40.7, 28.0, 16.3; IR (ATR) 2934, 1684, 1587, 1486, 1398, 1275, 1204, 1091, 1044, 970, 888, 817, 750 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{18}H_{18}ClBrNO_2$ 394.0209, found 394.0213 [M + H^+]. **3,3′-{5-Bromo-2-[1-(methoxyimino)ethyl]-1,3-phenylene}bis[1-(4-chlorophenyl)propan-1-one] (3dg′)**: colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.90 (d, *J* = 8.6 Hz, 4H), 7.43 (d, *J* = 8.6 Hz, 4H), 7.30 (s, 2H), 3.83 (s, 3H), 3.44−2.76 (m, 8H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 197.4, 155.4, 141.7, 139.7, 136.1, 134.9, 130.4, 129.5, 129.0, 122.6, 61.8, 40.4, 27.8, 17.3; IR (ATR) 2933, 1682, 1586, 1486, 1397, 1362, 1277, 1200, 1090, 1042, 980, 907, 882, 776, 524 cm^{-1}; HR-MS (ESI) *m/z* calcd for $C_{27}H_{25}Cl_2BrNO_3$ 560.0395, found 560.0397 [M + H^+].

Methyl 4-{3-{5-Bromo-2-[1-(methoxyimino)ethyl]phenyl}propanoyl}benzoate (3dh). The general procedure was followed using **1d** (57.0 mg, 0.25 mmol) and **2h** (95.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3dh** (60 mg, 57%) as a colorless solid: mp = 78−80 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 8.11 (d, *J* = 8.4 Hz, 2H), 8.00 (d, *J* = 8.4 Hz, 2H), 7.44 (d, *J* = 2.0 Hz, 1H), 7.38

DOI: 10.1021/acs.joc.6b02672
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(dd, J = 8.2, 2.0 Hz, 1H), 7.12 (d, J = 8.2 Hz, 1H), 3.95 (s, 3H), 3.86 (s, 3H), 3.39−3.31 (m, 2H), 3.11−3.06 (m, 2H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 198.4, 166.2, 155.3, 141.4, 139.9, 136.2, 134.0, 133.0, 130.2, 129.9, 129.6, 127.9, 122.6, 61.9, 52.4, 41.1, 28.0, 16.3; IR (ATR) 2933, 2261, 1724, 1431, 1236, 809, 669 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{20}H_{20}BrNO_4$ 417.0576, found 417.0578 [M + H$^+$].

3-{5-Bromo-2-[1-(methoxyimino)ethyl]phenyl}-1-(3-chlorophenyl)propan-1-one (3di). The general procedure was followed using **1d** (57.0 mg, 0.25 mmol) and **2i** (83.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3di** (78 mg, 79%) as a colorless solid: mp = 71−72 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.92 (t, J = 1.8 Hz, 1H), 7.82 (d, J = 7.8 Hz, 1H), 7.55−7.50 (m, 1H), 7.43 (d, J = 1.8 Hz, 1H), 7.41−7.35 (m, 2H), 7.12 (d, J = 8.2 Hz, 1H), 3.87 (s, 3H), 3.34−3.26 (m, 2H), 3.09−3.05 (m, 2H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 197.5, 155.3, 141.4, 138.3, 136.2, 135.0, 133.0, 133.0, 130.2, 130.0, 129.6, 128.2, 126.1, 122.6, 61.9, 40.8, 28.0, 16.3; IR (ATR) 2938, 1687, 1587, 1586, 1423, 1364, 1264, 1202, 1044, 908, 748 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{18}H_{18}ClBrNO_2$ 394.0209, found 394.0213 [M + H$^+$].

3-[3-(Benzo[*d*][1,3]dioxol-5-yl)-3-oxopropyl]-4-[1-(methoxyimino)ethyl]benzonitrile (3lj). The general procedure was followed using **1l** (44.0 mg, 0.25 mmol) and **2j** (88.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 8:1) yielded **3lj** (75 mg, 86%) as a slight yellow solid: mp = 100−101 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.59 (d, J = 1.4 Hz, 1H), 7.57−7.50 (m, 2H), 7.42 (d, J = 1.4 Hz, 1H), 7.35 (d, J = 8.0 Hz, 1H), 6.84 (dd, J = 8.1, 3.6 Hz, 1H), 6.04 (s, 2H), 3.91 (s, 3H), 3.32−3.20 (m, 2H), 3.19−3.08 (m, 2H), 2.21 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 196.5, 154.8, 151.9, 148.3, 141.8, 141.0, 133.7, 131.5, 129.9, 129.4, 124.2, 118.5, 112.3, 107.9, 107.8, 101.9, 62.1, 39.9, 28.0, 16.2; IR (ATR) 2934, 2227, 1674, 1611, 1490, 1400, 1260, 1035, 871, 829, 750 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{20}H_{19}N_2O_4$ 351.1345, found 351.1347 [M + H$^+$].

3-[3-(Furan-2-yl)-3-oxopropyl]-4-[1-(methoxyimino)ethyl]-benzonitrile (3lk). The general procedure was followed using **1l** (44.0 mg, 0.25 mmol) and **2k** (61.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3lk** (67 mg, 91%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.60 (dd, J = 2.9, 1.7 Hz, 2H), 7.53 (dd, J = 8.0, 1.6 Hz, 1H), 7.35 (d, J = 8.0 Hz, 1H), 7.20 (d, J = 3.6 Hz, 1H), 6.55 (dd, J = 3.6, 1.7 Hz, 1H), 3.94 (s, 3H), 3.25−3.09 (m, 4H), 2.22 (s, 3H).^{13}C NMR ($CDCl_3$, 100 MHz) δ = 187.7, 154.7, 152.5, 146.5, 141.8, 140.6, 133.7, 130.0, 129.4, 118.4, 117.2, 112.3, 62.0, 39.7, 27.4, 16.1; IR (ATR) 2937, 2819, 2230, 1672, 1568, 1468, 1365, 1260, 1043, 883, 764 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{17}H_{17}N_2O_3$ 297.1239, found 297.1244 [M + H$^+$].

3-[3-(Benzofuran-2-yl)-3-oxopropyl]-4-[1-(methoxyimino)-ethyl]benzonitrile (3ll). The general procedure was followed using **1l** (44.0 mg, 0.25 mmol) and **2l** (86.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3ll** (80 mg, 93%) as an off-white solid: mp = 75−77 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.70 (d, J = 7.9 Hz, 1H), 7.63 (d, J = 1.3 Hz, 1H), 7.56 (d, J = 8.4 Hz, 1H), 7.53 (dd, J = 8.0, 1.6 Hz, 1H), 7.51 (s, 1H), 7.50−7.45 (m, 1H), 7.36 (d, J = 8.0 Hz, 1H), 7.31 (t, J = 7.5 Hz, 1H), 3.94 (s, 3H), 3.37−3.30 (m, 2H), 3.24−3.16 (m, 2H), 2.23 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 189.6, 155.6, 154.7, 152.3, 141.8, 140.5, 133.8, 130.0, 129.4, 128.4, 127.0, 124.0, 123.3, 118.4, 112.8, 112.4, 112.4, 62.1, 40.4, 27.5, 16.1; IR (ATR) 2939, 2818, 2224, 1672, 1557, 1364, 1259, 1156, 1042, 992, 882, 833, 732 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{21}H_{19}N_2O_3$ 347.1396, found 347.1399 [M + H$^+$].

3-{2-[1-(Methoxyimino)ethyl]thiophen-3-yl}-1-(thiophen-2-yl)propan-1-one (3wm). The general procedure was followed using **1w** (78.0 mg, 0.50 mmol) and **2m** (138 mg, 1.00 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3wm** (60 mg, 41%) as a slight yellow oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.68 (dd, J = 3.8, 1.0 Hz, 1H), 7.60 (dd, J = 4.9, 1.0 Hz, 1H), 7.20 (d, J = 5.1 Hz, 1H), 7.12−7.06 (m, 1H), 6.95 (d, J = 5.1 Hz, 1H), 3.91 (s, 3H), 3.25 (s, 4H), 2.24 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 192.6, 150.7, 144.4, 139.8, 134.4, 133.4, 131.8, 131.0, 124.7, 62.0, 40.0, 25.1, 15.8; IR (ATR) 2943, 2260, 1714, 1431, 1236, 809, 669 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{16}NO_2S_2$ 294.0622, found 294.0625 [M + H$^+$].

4-[2-(Pyridin-2-yl)phenyl]butan-2-one (5a). The general procedure was followed using **4a** (39.0 mg, 0.25 mmol) and **2b** (35.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **5a** (21 mg, 37%; 26 mg, 46%, 70 °C) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 8.66 (d, J = 4.7 Hz, 1H), 7.75 (dt, J = 7.8, 1.9 Hz, 1H), 7.40 (d, J = 7.8 Hz, 1H), 7.36−7.23 (m, 5H), 2.99−2.92 (m, 2H), 2.74−2.63 (m, 2H), 2.04 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 208.2, 160.0, 149.1, 140.4, 139.1, 136.4, 129.9, 129.8, 128.6, 126.3, 124.0, 121.8, 45.4, 29.8, 27.5; IR (ATR) 2942, 1707, 1515, 1233, 759 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{15}H_{16}NO$ 226.1232, found 226.1235 [M + H$^+$]. The spectral data were in accordance with those reported in the literature.[18a]

4-[2-(Pyrimidin-2-yl)phenyl]butan-2-one (5b). The general procedure was followed using **4b** (39.0 mg, 0.25 mmol) and **2b** (35.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 14 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **5b** (27 mg, 48%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 8.83 (d, J = 4.8 Hz, 2H), 7.84 (dd, J = 7.5, 1.4 Hz, 1H), 7.42−7.28 (m, 3H), 7.23 (t, J = 4.8 Hz, 1H), 3.21−3.10 (m, 2H), 2.87−2.77 (m, 2H), 2.11 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 208.4, 167.4, 157.0, 140.5, 137.8, 130.9, 130.6, 129.8, 126.4, 118.7, 45.9, 29.9, 28.2; IR (ATR) 2920, 1709, 1553, 1413, 1160, 756, 634 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{15}N_2O$ 227.1184, found 227.1188 [M + H$^+$].

4,4′-[2-(1*H*-Pyrazol-1-yl)-1,3-phenylene]dibutan-2-one (5c). The general procedure was followed using **4c** (36.0 mg, 0.25 mmol) and **2b** (35.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **5c** (54 mg, 76%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.71 (d, J = 1.6 Hz, 1H), 7.53 (d, J = 2.3 Hz, 1H), 7.30 (d, J = 7.6 Hz, 1H), 7.18 (d, J = 7.6 Hz, 2H), 6.46 (t, J = 2.3 Hz, 1H), 2.73−2.36 (m, 8H), 2.03 (s, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 207.4, 140.1, 139.6, 138.8, 131.5, 129.6, 128.0, 106.4, 44.6, 29.8, 25.6; IR (ATR) 2937, 2724, 1716, 1584, 1394, 1304, 1186, 1042, 882, 751 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{17}H_{21}O_2N_2$ 285.1603, found 285.1607 [M + H$^+$].

4-[2-(1*H*-Indazol-1-yl)thiophen-3-yl]butan-2-one (5d). The general procedure was followed using **4d** (50.0 mg, 0.25 mmol) and **2b** (35.0 mg, 0.50 mmol) in TFE/MeOH (0.9−0.1 mL) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **5d** (66 mg, 98%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 8.20 (s, 1H), 7.77 (d, J = 8.1 Hz, 1H), 7.43−7.37 (m, 1H), 7.34 (d, J = 8.1 Hz, 1H), 7.28−7.25 (m, 1H), 7.22 (t, J = 7.4 Hz, 1H), 6.96 (d, J = 5.6 Hz, 1H), 2.74−2.66 (m, 2H), 2.64−2.60 (m, 2H), 2.01 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 207.4, 141.7, 137.9, 136.1, 134.7, 127.6, 127.5, 124.2, 123.8, 121.8, 121.1, 110.2, 43.8, 29.8, 21.8; IR (ATR) 2920, 1714, 1567, 1466, 1355, 1275, 1162, 948, 750, 624 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{15}H_{15}N_2OS$ 271.0905, found 271.0907 [M + H$^+$].

3xa and 3xa′. The general procedure was followed using (4-fluorophenyl)(4-methoxyphenyl)methanone *O*-methyl oxime **1x** (65.0 mg, 0.25 mmol) and **2a** (35.0 mg, 0.50 mmol) for 4 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded the mixture of products **3xa** and **3xa′** (55 mg, 69%) as a colorless oil. The ratio of the products was estimated by ^{1}H NMR and ^{19}F NMR spectroscopy (**3xa**/**3xa′** 1:1): ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 9.70 (s, 1H), 9.67 (s, 1H), 7.52−7.44 (m, 4H), 7.25−7.20 (m, 1H), 7.12 (dd, J = 7.4, 1.4 Hz, 1H), 7.08−7.01 (m, 2H), 6.97−6.91 (m, 2H), 6.89−6.84 (m, 2H), 6.79−6.73 (m, 2H), 3.98 (s, 3H), 3.96 (s, 3H), 3.81 (s, 3H), 3.80 (s, 3H), 2.91−2.80 (m, 4H), 2.71−2.58 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 201.2, 200.8, 162.9 (d, J_{C-F} = 248.6 Hz), 162.8 (d, J_{C-F} = 250.5 Hz), 160.4, 160.2, 154.9, 154.7, 142.3 (d, J_{C-F} = 7.6 Hz), 141.3, 132.8 (d, J_{C-F} = 3.2 Hz), 132.5 (d, J_{C-F} = 8.5 Hz), 132.2, 132.1 (d, J_{C-F} = 8.4 Hz), 131.8, 130.0 (d, J_{C-F} = 3.5 Hz), 128.7, 125.7, 116.6 (d,

DOI: 10.1021/acs.joc.6b02672
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J_{C-F} = 21.5 Hz), 115.7, 115.1 (d, J_{C-F} = 21.5 Hz), 113.5, 113.4 (d, J_{C-F} = 20.2 Hz), 111.7, 62.4, 62.3, 55.3, 55.3, 45.3, 44.9, 26.4, 26.0; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −110.4 (s), −112.5 (s); IR (ATR) 2936, 2837, 2723, 1722, 1604, 1506, 1256, 1159, 1045, 997, 840, 750 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{18}H_{19}FNO_3$ 316.1349, found 316.1353 [M + H$^+$].

4-{2-[1-(Methoxyimino)ethyl]-5-(trifluoromethyl)phenyl}-butan-2-one (3jb). The general procedure was followed using **1j** (1085 mg, 5.0 mmol) and **2b** (700 mg, 10 mmol) $[Cp^*RhCl_2]_2$ (55 mg, 1.8 mol %), $AgSbF_6$ (124 mg, 7.2 mol %), KOPiv (1400 mg, 2.0 equiv) for 12 h. Purification by column chromatography (*n*-hexane/EtOAc 10:1) yielded **3jb** (1.406 g, 98%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.50−7.46 (m, 2H), 7.38−7.31 (m, 1H), 3.95 (s, 3H), 3.00 (dd, *J* = 9.8, 5.8 Hz, 2H), 2.80 (dd, *J* = 9.8, 5.7 Hz, 2H), 2.20 (s, 3H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 207.1, 155.1, 140.7, 140.1, 130.6 (q, J_{C-F} = 32.4 Hz), 129.1, 126.6 (q, J_{C-F} = 3.7 Hz), 123.9 (q, J_{C-F} = 272.4 Hz), 123.2 (q, J_{C-F} = 3.7 Hz), 61.9, 45.2, 29.8, 27.5, 16.2; ^{19}F NMR ($CDCl_3$, 376 MHz) δ −62.76 (s); IR (ATR) 1716, 1414, 1332, 1276, 1123, 1045, 897, 834, 750 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{17}F_3NO_2$ 288.1211, found 288.1215 [M + H$^+$].

General Procedure and Characterization Data for the Synthesis of 10. A suspension of 4-{2-[1-(methoxyimino)ethyl]-5-(trifluoromethyl)phenyl}butan-2-one (**3jb**) (144 mg, 0.50 mmol), Cu (64.0 mg, 2.0 equiv), and HCl (6.0M, 1.67 mL) in 1,4-dioxane (1.0 mL) was stirred at 80 °C for 2.5 h.[19] After being cooled to room temperature, the reaction mixture was extracted with EtOAc (3 × 10 mL)/aqueous $NaHCO_3$. The combined organic layers were dried over Na_2SO_4 and filtered. The solvent was concentrated in vacuo, and purification by column chromatography (*n*-hexane/EtOAc 15:1) yielded **10** (70 mg, 52%) as a colorless oil: ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.63 (s, 1H), 7.57 (d, *J* = 8.0 Hz, 1H), 7.41 (d, *J* = 8.0 Hz, 1H), 3.99 (s, 3H), 3.63 (d, *J* = 2.0 Hz, 2H), 2.35 (t, *J* = 2.1 Hz, 3H), 2.18 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ = 153.3, 150.1, 142.5, 139.0, 137.8, 127.5 (q, J_{C-F} = 31.8 Hz), 124.8 (q, J_{C-F} = 272.3 Hz), 123.8 (q, J_{C-F} = 3.9 Hz), 120.1 (q, J_{C-F} = 3.8 Hz), 119.4, 61.9, 39.6, 14.3, 12.6; ^{19}F NMR ($CDCl_3$, 376 MHz) δ = −61.46 (s); IR (ATR) 2940, 1716, 1414, 1332, 1277, 1161, 1123, 1046, 897, 834, 750 cm^{-1}; HR-MS (ESI) m/z calcd for $C_{14}H_{14}F_3NO$ 269.1027, found 269.1031 [M + H$^+$].

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b02672.

Characterization of new compounds (^{1}H, ^{13}C, ^{19}F NMR and NOESY spectra) and mechanistic studies (KIE experiments, etc.) (PDF)

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Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (Grant No. 21602083) and National Natural Science Foundation of Jiangsu Province (Grant No. BK20160160).

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DOI: 10.1021/acs.joc.6b02672
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