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Synthesis of 2-Acyl-3,4-Dihydronaphthalenes by Silver-Promoted Oxidative C−C σ–Bond Acylation/Arylation of Alkylidenecyclopropanes with α-Ketoacids

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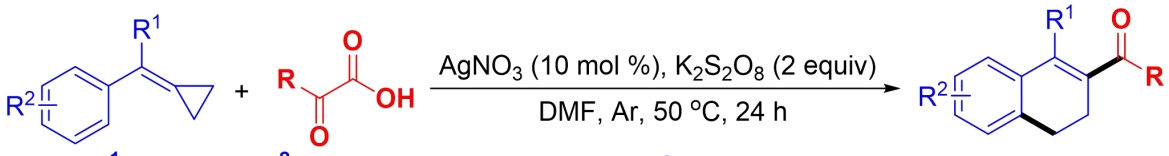
Abstract



- **Oxidative radical C-C bond difunctionalization strategy**
- **Acylation and arylation of C-C σ-bond in MCPs**
- **General: 45 examples, up to 88% yield**

A novel and efficient $AgNO_3$-facilitated oxidative C–C σ–bond difunctionalization of alkylidenecyclopropanes with α-ketoacids for preparing 2-acyl-substituted 3,4-dihydronaphthalenes is

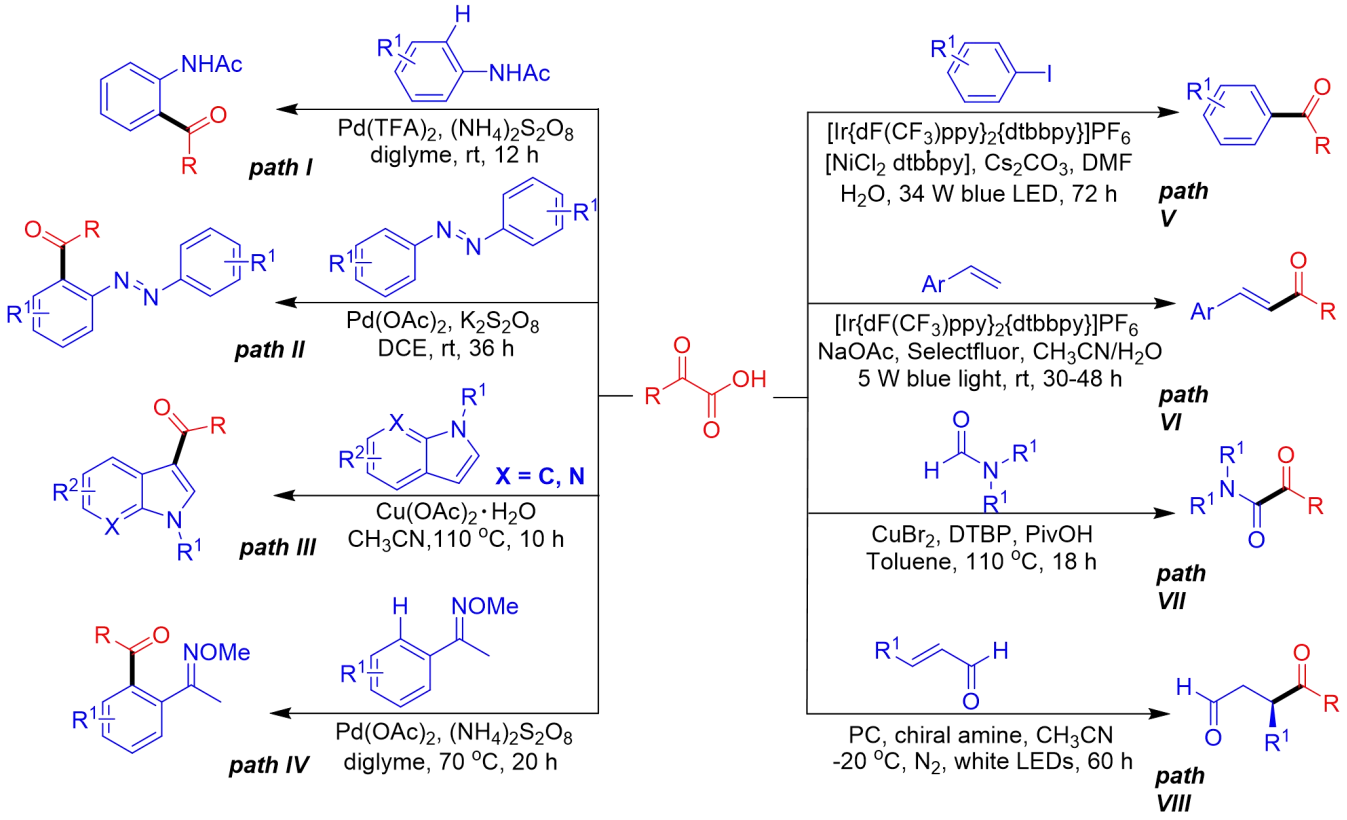
developed. This radical acylation/arylation transformation proceeds *via* decarboxylation of *α*-ketoacid, acylation of carbon–carbon double bond, cleavage of carbon–carbon σ–bond and cyclization with connected aromatic ring, and offers a mild and facile strategy for acylation/arylation of carbon–carbon *σ*–bonds with an acyl radical and an aromatic ring to build two new carbon–carbon bonds. This method uses an inexpensive oxidant, features a wide substrate scope, and is operationally simple.

Introduction

Due to the stabilities of carbon–carbon *σ*–bonds, the cleavage and functionalization of carbon–carbon *σ*–bonds is a challenging task.[1] New strategies for radical carbon–carbon *σ*–bond functionalization have become a recent interesting topic and arouse chemists' wide concern because they provide new approaches for preparing complex biological scaffolds and natural products.[2] Recently, many novel methods featuring carbon–carbon *σ*–bond difunctionalization for constructing two new chemical bonds have been reported and have also been widely used in lots of different substrates.[3,4] Especially, small ring compound, including three-membered[5] and four-membered carbocycles,[6] are ideal raw materials for accessing bicyclic or polycyclic structures.

Carboxylic acids are a class of common compounds, which are widely used in organic and pharmaceutical synthesis.[7] In past several years, the decarboxylation of carboxylic acids have become efficient tools for introducing aryl or alkyl groups into organic compounds by avoiding the preparation of prefunctionalized starting materials and the usage of stoichiometric transition-metal-catalysis.[8] Most recently, *α*-ketoacids, as acylating reagents, presented high value in constructing ketones. These transformations underwent decarboxylation of *α*-ketoacids to deliver acyl free radicals and CO_2 (Scheme 1).[9–10] In 2010, Ge's group developed the Pd-mediated *ortho*-acylation of acetanilides with acyl radicals, which came from decarboxylation of *α*-ketoacids (path I).[9a] In 2013, Wang and co-workers presented a facile and mild method to access acylated azo compounds by decarboxylation of *α*-ketoacids and *ortho*-acylation of azobenzenes (path II).[9b] In the same year, this group reported a copper-facilitated decarboxylative acylation of C3-position in indoles with *α*-ketoacids to prepare 3-acylindoles (path III).[9c] Kim et al. reported a mild and simple Pd-catalyzed acylation of *ortho*-position in *o*-methyl

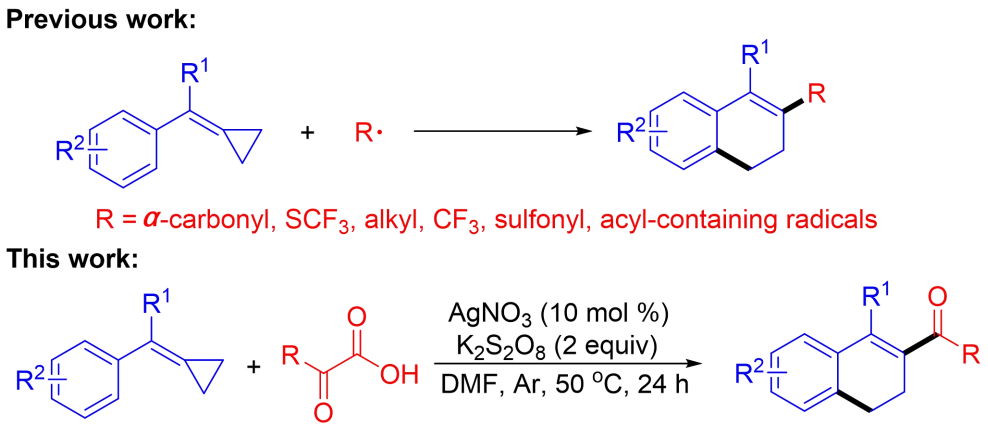
ketoximes with α-ketoacids *via* carbon–hydrogen bond activation and decarboxylative cross-coupling reaction (path IV).[9d] In 2015, MacMillan and co-workers presented the direct decarboxylative cross-coupling of α-ketoacids with aryl halides for constructing aryl and alkyl ketone architectures (path V).[9e] Zhu's group developed a visible-light-catalyzed decarboxylative cross-coupling of α-ketoacids with alkenes for the preparation of α,β-unsaturated ketones *via* domino-fluorination-protodefluorination process (path VI).[9f] Wang's group reported the copper-mediated decarboxylative acylation of C(sp^2)–H bonds in formamides with α-ketoacids to synthesize α-ketoamides (path VII).[9g] Yu et al. developed an enantioselective and new visible-light/amine-cocatalyzed hydroacylation of enals with acyl radicals, which generated from decarboxylation of α-ketoacids (path VIII).[9h]



Scheme 1. Selected Decarboxylative Acylation Reactions of α-Ketoacids

Alkylidenecyclopropanes (ACPs) are readily accessible molecules though the carbocyclic skeletons possess large ring tensions. Due to their unique properties, ACPs are often used as important starting materials in chemical industry and organic synthesis.[11] Recently, many approaches for radical carbon–

carbon σ–bond difunctionalization ACPs were developed.[12-13] A variety of radicals, such as α-carbonyl,[13a,b] SCF_3,[13c] alkyl,[13d] CF_3,[13e] ArS,[13f] sulfonyl,[13g] acyl,[13h] P[13i]-containing radicals could be applied in these transformations. Based on these results, we developed a facile and efficient carbon–carbon σ–bond difunctionalization strategy for convenient constructing 2-acyl-substituted 3,4-dihydronaphthalene compounds. The process is facilitated by a silver catalyst[14] and results in C–C bond acylation/arylation of ACPs with an acyl radical and an aromatic ring. In these transformations, the acyl radicals come from decarboxylation of α-ketoacids (Scheme 2).



Scheme 2. Radical Carbon–Carbon σ–Bonds Difunctionalization in ACPs

Results and Discussion

We began to investigate the best reaction conditions by using 1-(benzyloxy)-2-(cyclopropylidene-methyl)-benzene (**1a**) and phenylglyoxylic acid (**2a**) as the model reaction (Table 1). To our delight, the target product (8-(benzyloxy)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone **3aa** could be obtained in 88% yield by using $AgNO_3$ (10 mol%) as catalyst and $K_2S_2O_8$ (2 equiv) as oxidant in DMF (2 mL) at 50 °C for 24 hours (entry 1). Next, we investigated the effect of other silver catalysts. The results showed that the silver catalysts could promote the reaction. The difunctionalization reaction conducted without $AgNO_3$ could also deliver the expected product **3aa** in 26% yield (entry 2). A series of other silver salts, including Ag_2CO_3, Ag_2SO_4, AgF, AgSCN, and $AgIO_3$, were examined. However, all of them gave

lower yield than that of $AgNO_3$ (entries 3–7 vs. entry 1). Reducing or increasing the loading of $AgNO_3$ could not give higher reaction yields (entries 8–9).

Table 1. Screening Optimal Conditions[a]

1a **2a** **3aa**

entry	variation from the standard conditions	yield (%)[b]
1	none	88
2	without $AgNO_3$	26
3	Ag_2CO_3 instead of $AgNO_3$	31
4	Ag_2SO_4 instead of $AgNO_3$	43
5	AgF instead of $AgNO_3$	35
6	AgSCN instead of $AgNO_3$	30
7	$AgIO_3$ instead of $AgNO_3$	51
8	$AgNO_3$ (5 mol %)	61
9	$AgNO_3$ (20 mol %)	85
10[c]	without $K_2S_2O_8$	0
11	$(NH_4)_2S_2O_8$ instead of $K_2S_2O_8$	70
12	oxone instead of $K_2S_2O_8$	46
13[c]	DDQ instead of $K_2S_2O_8$	0
14[c]	BQ instead of $K_2S_2O_8$	0
15[c]	$PhI(OAc)_2$ instead of $K_2S_2O_8$	0
16	DTBP instead of $K_2S_2O_8$	13
17	benzene instead of DMF	41
18	dioxane instead of DMF	18
19	^{n}BuOAc instead of DMF	25
20	acetone instead of DMF	40
21[c]	DMSO instead of DMF	trace
22	at 70 °C	75
23	at 30 °C	60
24	under air atmosphere	80
25	for 48 h	87
26[d]	none	73

[a] Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol, 1.5 equiv), $AgNO_3$ (10 mol %), $K_2S_2O_8$ (0.4 mmol, 2 equiv) and solvent (2 mL) at 50 °C under an argon atmosphere for 24 h. [b] Isolated yield. [c] Over 85% of raw material **1a** was recovered, and the rest was decomposed. [d] **1a** (1 g, 4.24 mmol) and solvent (10 mL) for 72 h.

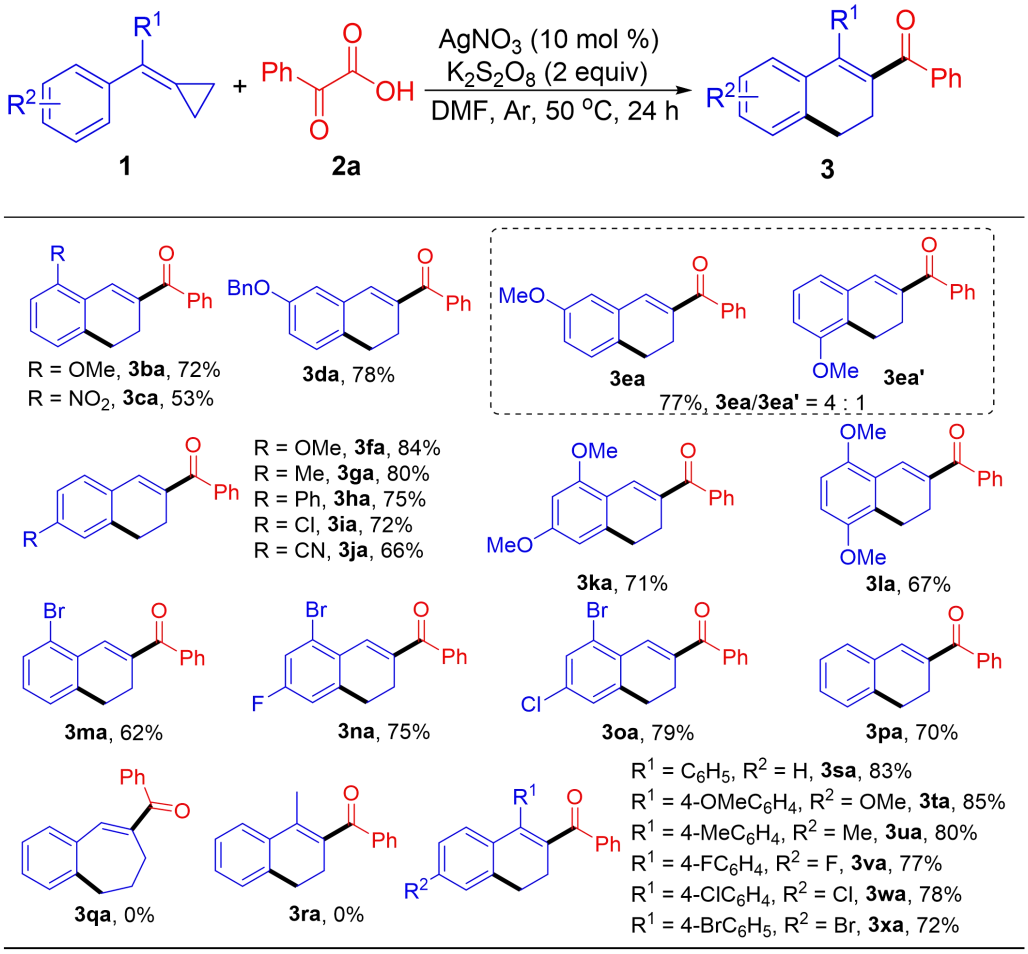
According to the experimental result, $K_2S_2O_8$ was indispensable for the acylation/arylation reaction

(entry 10). Prompted by this results, a number of other oxidants, such as $(NH_4)_2S_2O_8$, $KHSO_5$ (oxone), 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ), 1,4-benzoquinone (BQ), $PhI(OAc)_2$ and di-*tert*-butyl peroxide (DTBP), were subsequently tested (entries 11–16). None of them was superior than $K_2S_2O_8$ and the reaction could afford the product **3aa** in moderate yields by using $(NH_4)_2S_2O_8$ or oxone (entries 11 and 12). However, DDQ, BQ, and $PhI(OAc)_2$ were not suitable for this decarboxylative difunctionalization (entries 13–15). Various solvents, such as benzene, dioxane, ^{n}BuOAc, acetone, and DMSO, were also surveyed, revealing that DMF is the best suited solvent (entries 17–21). However, variation of reaction temperatures to 70 °C or 30 °C led to lower reaction yields (entries 22–23). The target product could also be obtained in good yield when the difunctionalization reaction was conducted in air atmosphere (entry 24). Additionally, a longer reaction time afforded a similar yield (entry 25). To our delight, a large scale experiment, which was carried out with 1 g of ACP **1a**, could delivere the product **3aa** in moderate yield (entry 26).

Based on the established conditions, we set out to examine the scope of ACPs **1** with 2-oxo-2-phenylacetic acid **2a**. As shown in Table 2, the results suggested that this acylation/arylation could be applied to a variety of ACPs **1b**–**p**, including ACPs with monosubstituted aryl group, disubstituted aryl group, trisubstituted aryl group and unsubstituted aryl group. The standard conditions were suitable for many ACPs **1b**–**j** with one substituent, such as OMe, NO_2, OBn, Ph, Me, Cl, and CN groups on the connected aryl ring, and the activity order is *ortho* < *meta* < *para*. The electronic effect also affected the reaction and ACPs with electron-donating groups on the aryl groups delivered higher yields than that of ACPs with electron-withdrawing ones (products **3ba**–**ja**): ACPs **1a**–**j** were viable to furnish the target 2-acyl-substituted 3,4-dihydronaphthalenes **3ba**–**ja** in moderate to good yields, while using *meta*-substituted ACP **1d** under the standard conditions provided the single product **3da** in 78% yield. Another *meta*-substituted ACP **1e** could undergo this difunctionalization smoothly and the products (7-methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone **3ea** and (5-methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone **3ea'** could be isolated in 77% yield (4 : 1). Additionally, ACPs **1c** or **1j** with a

NO_2 group or a CN group on the connected aryl ring were suitable starting materials (**3ca** and **3ja**). Disubstituted ACPs **1k–l** could undergo this difunctionalization smoothly and afforded the desired products in moderate yields (products **3ka–la**). Halogen substituted ACPs **1m–o** were viable for the reaction with substrate **2a**, $AgNO_3$, and $K_2S_2O_8$, offering the corresponding halogen substituted 2-acyl-3,4-dihydronaphthalenes **3ma–oa** in moderate yields.

Table 2. Screening Scope of ACPs (**1**)[a]

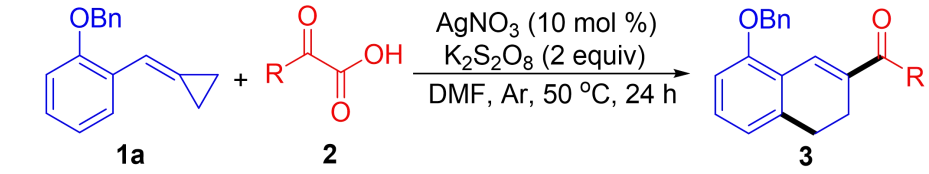


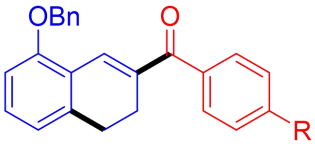
[a] Reaction conditions: **1a** (0.2 mmol), **2** (0.3 mmol, 1.5 equiv.), $AgNO_3$ (10 mol %), $K_2S_2O_8$ (0.4 mmol, 2 equiv), DMF (2 mL), at 50 °C under an argon atmosphere for 24 h.

To our delight, ACP **1p** with an unsubstituted aryl group could also afford the ring-opening and cyclization product **3pa** in 70% yield under the optimal conditions. However, the seven-membered cyclic product **3qa** could not be obtained when a four-membered carbocyclic substrate **1q** (methylenecyclobutane) was used under standard conditions. Disubstituted substrate **1r** ((1-

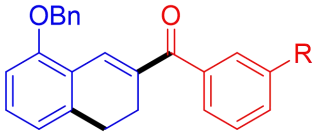
cyclopropylideneethyl)benzene) with a phenyl group and a methyl group (R^1 = Me) at the terminal carbon of the double bond was an unsuitable substrate (product **3ra**). Next, the corresponding products **3sa**–**xa** could be obtained in good yields when a serial of diaryl substituted ACPs **1s**–**x** (R^1 = Ar) were employed into this carbon−carbon *σ*–bonds acylation/arylation.

Table 3. Screening Scope of *α*-Ketoacids (**2**) [a]

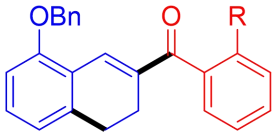




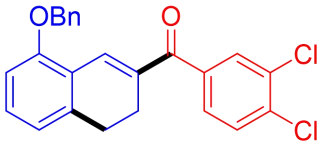
R = OMe, **3ab**, 87%
R = SMe, **3ac**, 79%
R = Me, **3ad**, 82%
R = ^{i}Pr, **3ae**, 87%
R = Ph, **3af**, 80%
R = F, **3ag**, 77%
R = Cl, **3ah**, 75%
R = Br, **3ai**, 66%
R = CF_3, **3aj**, 61%
R = NO_2, **3ak**, 0%[b]



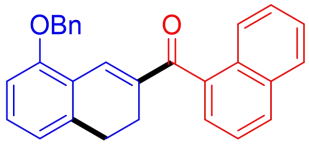
R =OMe, **3al**, 82%
R = Me, **3am**, 76%
R = Cl, **3an**, 70%



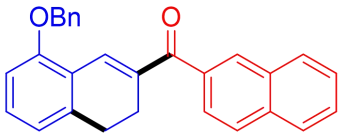
R = Me, **3ao**, 74%
R = F, **3ap**, 71%
R = Cl, **3aq**, 62%



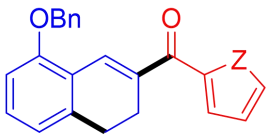
3ar, 58%



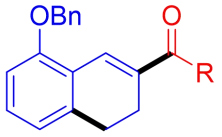
3as, 66%



3at, 61%



Z = S, **3au**, 52%
Z = O, **3av**, 50%



R = Me, **3aw**, 56%
R = ^{t}Bu, **3ax**, 0%[b]

[a] Reaction conditions: **1a** (0.2 mmol), **2** (0.3 mmol, 1.5 equiv), $AgNO_3$ (10 mol %), $K_2S_2O_8$ (0.4 mmol, 2 equiv), DMF (2 mL), at 50 °C under an argon atmosphere for 24 h. [b] Over 70% of raw material **1a** was recovered, and the rest was decomposed.

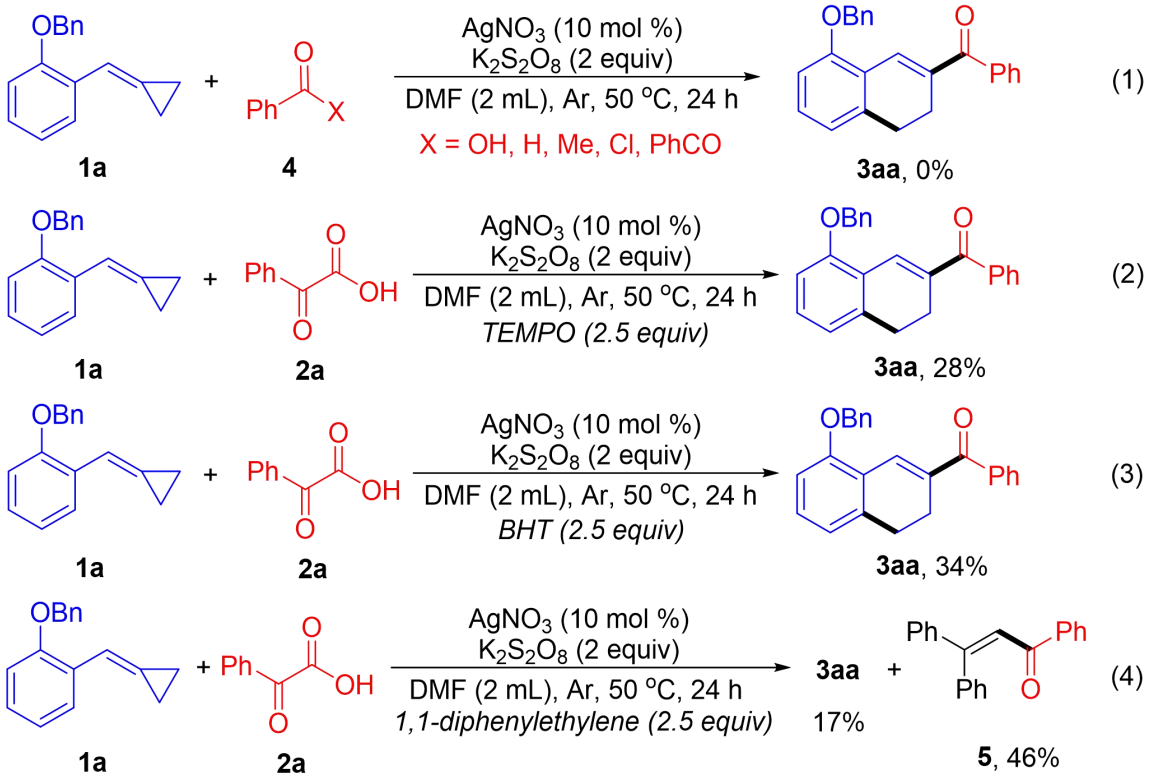
Subsequently, we began to investigate the applicability of substituted *α*-ketoacids **2** for this radical difunctionalization process by using ACP **1a** as reaction partener (Table 3)**.** A wide range of *α*-ketoacids **2b**–**w**, including functionalized aryl *α*-ketoacids (**2b**–**t**), heterocyclic *α*-ketoacids (**2u**–**v**) and aliphatic *α*-ketoacids (**2w**), were examined. The standard conditions were suitable for a variety of aryl *α*-ketoacids with different substituents, such as OMe, SMe, Me, ^{i}Pr, Ph, F, Cl, Br, CF_3 and dichloro groups on the

aryl ring (products **3ab**–**ar**), and the steric effect of the substituents affected the reaction yields (products **3ad**, **3am** and **3ao**). The electronic effect of the substituents also had influence on this transformation, and electron-withdrawing groups substituted *α*-ketoacids delivered lower yields than that of electron-donating groups substituted ones (products **3ab**–**ar**): *α*-ketoacids **2b**–**j** were viable to furnish the corresponding 2-acyl-substituted 3,4-dihydronaphthalenes **3ab**–**aj** in moderate to good yields. While using 2-(4-isopropylphenyl)-2-oxoacetic acid **2e**, the target (8-(benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-isopropylphenyl)methanone **3ae** was obtained in 87% yield. However, *para*-NO_2-substituted aryl *α*-ketoacid **2k** had no reactivity (product **3ak**). To our delight, disubstituted aryl *α*-ketoacid **2r** was viable for the reaction with ACP **1a**, $AgNO_3$, and $K_2S_2O_8$, offering the corresponding product **3ar** in moderate yield. To our surprise, 2-(naphthalen-1-yl)-2-oxoacetic acid (**2s**) and 2-(naphthalen-2-yl)-2-oxoacetic acid (**2t**) were compatible for this transformation (products **3as** and **3at**). The heterocyclic *α*-ketoacids **2u** and **2v** have been also utilized for this reaction. We found that the corresponding products **3au** and **3av** formed in moderate yields under the standard conditions. Additionally, aliphatic *α*-ketoacid **2w** was also suitable for this reaction system, and delivered the difunctional product **3aw** in 56% yield. However, 3,3-dimethyl-2-oxobutanoic acid **2x** was not compatible with the standard conditions. The target product **3ax** could not be obtained and most of the starting material **1a** was recovered. The 3,3-dimethylpropyl acyl radical, which generated from *α*-ketoacid **2x**, was easily to decompose into *tert*-butyl radical *via* decarbonylation. The addition of *tert*-butyl radical to carbon–carbon double bond in ACPs was very difficult due to the steric effect.

Finally, a range of other acyl radical sources **4**, including benzoic acid, benzaldehyde, acetophenone, benzoyl chloride, and benzil were employed for this difunctionalization reaction. The experimental results indicated that these acyl radical sources were not suitable for this acylation/arylation reaction (eq 1, Scheme 3). According to previous literature, the reaction may contain a radical-type pathway.[9–13] Thus, several control experiments were performed by adding corresponding radical inhibitors, such as TEMPO, BHT, or 1,1-diphenylethylene. The yield of the product **3aa** was dramatically declined (eqs 2–

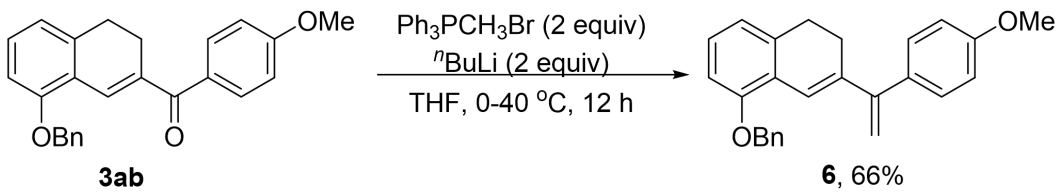
4, Scheme 3). The product **5** (1,3,3-triphenylprop-2-en-1-one) could be obtained in 46% yield and the target product **3aa** could only be isolated in very low yield when 1,1-diphenylethylene (2.5 equiv) was added into the reaction. These results indicated that a radical process could be definitely contained in this transformation.[9,13]

Scheme 3. Control Experiments.



Alkenes are important intermediates in organic synthesis. They can be used in a lot of transformation, such as cross-coupling reaction,[15] difunctionalization reaction,[16] polymerization reaction[17] and so on. Thus, we prepared the alkene **6** from the product **3ab** through condensation reaction between the carbonyl group and methyltriphenylphosphonium bromide (Scheme 4).

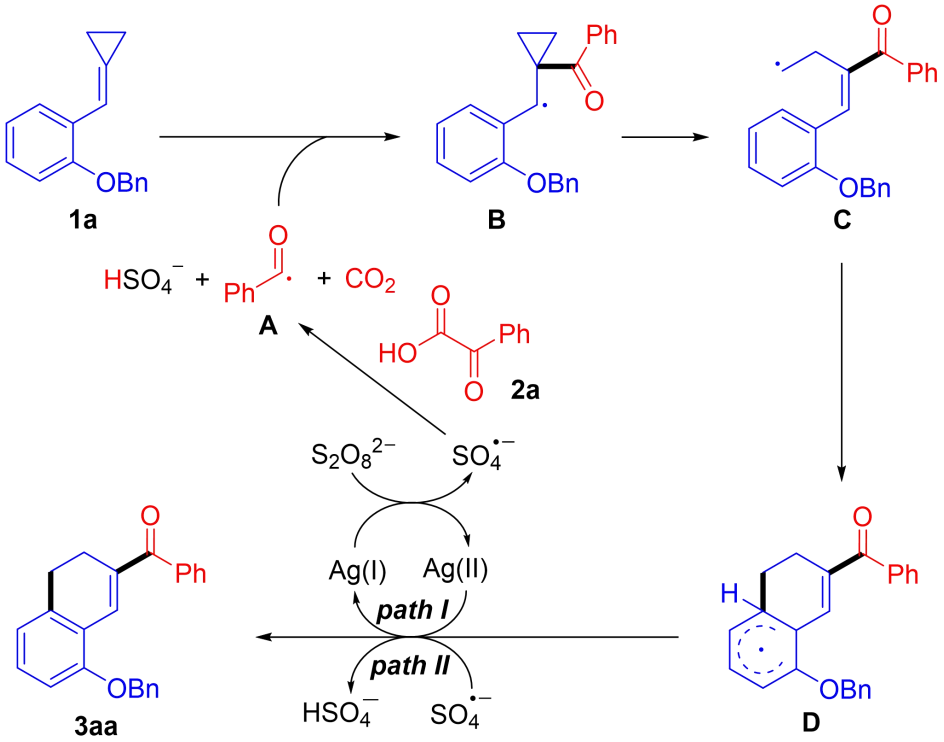
Scheme 4. Utilizations of products **3**



The reaction mechanism for the decarboxylative difunctionalization reaction was proposed

according to previous literature and these experimental results (Scheme 5).[9–14] Initially, $S_2O_8^{2-}$ oxidizes Ag^{I} into Ag^{II} along with generating $SO_4^{\bullet-}$, which triggers decarboxylation of α-oxocarboxylic acid **2a** to give the acyl radical **A**. Then, the acyl radical **A** attacks the double bond of ACP **1a** to afford the more stable benzyl radical **B**. The alkyl radical **C**, which is formed from ring-opening of intermediate **B**, undergoes intramolecular cyclization with an aryl ring to furnish radical **D**. Finally, oxidation and deprotonation of intermediate **D** to afford the target product **3aa** by the oxidation of $SO_4^{\bullet-}$. Importantly, $SO_4^{\bullet-}$ oxidation process is undoubtedly contained in the last step, because this difunctionalization reaction can still occur in absence of $AgNO_3$. However, the last aromatization process can also be performed under the action of Ag^{II}, because $AgNO_3$ is important for this reaction, and in accordance with the low efficiency of this transformation without $AgNO_3$.[13b,13g,14]

Scheme 5. Possible Mechanisms.



Conclusions

In summary, we have presented a novel and efficient $AgNO_3$-facilitated oxidative C–C σ–bond difunctionalization of alkylidenecyclopropanes with α-ketoacids to prepare 2-acyl-substituted 3,4-dihydronaphthalenes. This radical acylation/arylation transformation proceeds *via* decarboxylation of

α-ketoacid, acylation of carbon–carbon double bond, cleavage of carbon–carbon σ–bond and cyclization with connected aromatic ring, and offers a mild and facile strategy for acylation/arylation of carbon-carbon σ–bonds with an acyl radical and an aromatic ring to construct two new carbon–carbon bonds.

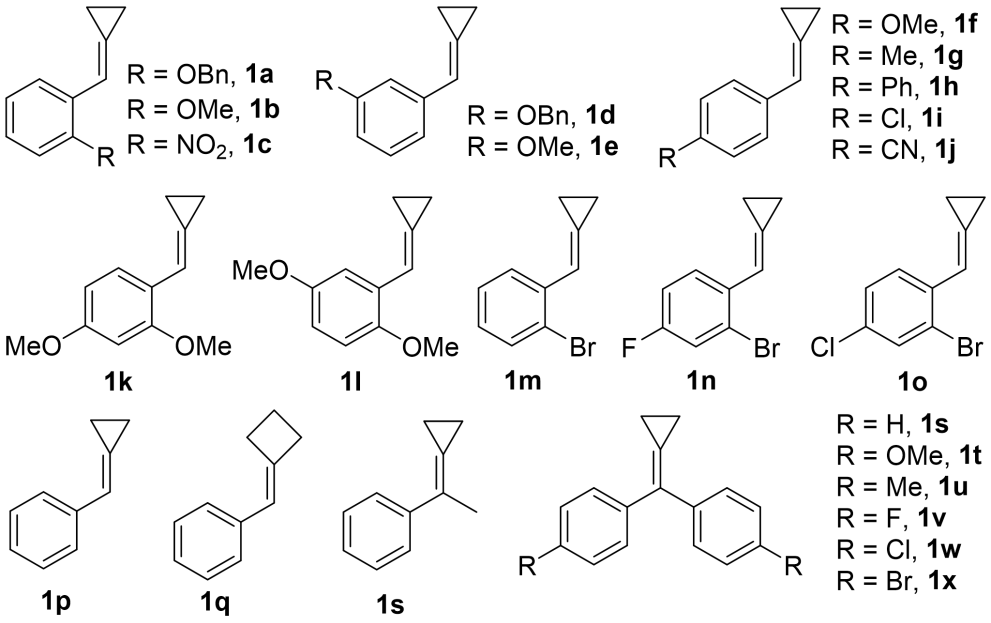
Experimental Section

General Considerations:

The ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ solvent on a NMR spectrometer using TMS as internal standard. LRMS was performed on a GC-MS instrument and HRMS was measured on an electrospray ionization (ESI) apparatus using time-of-flight (TOF) mass spectrometry. Melting points are uncorrected.

Preparation of ACPs 1 and α-Ketoacids:

ACPs 1[12] and α-ketoacids[9-10] were synthesized according to the literatures.



ACPs **1a**–**b**, **1d**–**i**, **1k, 1q, 1s**–**t**;[12g] **1m**–**o, 1u**–**x**;[12d] **1c, 1r, 1p**;[12h] **1j**, **1l**;[12e] α-ketoacid **2a**–**b**, **2d**, **2g**–**i**, **2m**–**o**, **2q**, **2s**–**t**, **2u**, **2w**;[10d] **2c**; **2f, 2j**–k**, 2p**;[9b] and **2l, 2n, 2r, 2v**;[9h] were reported in previous literatures, α-ketoacid **2e** was reported for the first time and its physical data and spectroscopic were presented as follow:

*2-(4-Isopropylphenyl)-2-oxoacetic acid (**2e**):*Yield: 1196.6 mg, 62%; yellow oil;^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.21(d, J = 8.0 Hz, 2H), 7.38 (d, J = 8.0 Hz, 2H), 5.32 (s, 1H), 3.05-2.95 (m, 1H), 1.28 (d,

J = 6.8 Hz, 6H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 184.7, 163.0, 157.6, 131.4, 127.1, 126.7, 34.5, 23.5. HRMS (ESI-TOF) *m/z*: $C_{11}H_{13}O_3$ $(M + H)^+$ calcd for 194.0859, found 194.0866.

Typical Experimental Procedure for the Synthesis of 2-acyl-3,4 -dihydronaphthalenes:

To a Schlenk tube were added ACPs **1** (0.2 mmol), *α*-ketoacids **2** (0.3 mmol, 1.5 equiv), $AgNO_3$ (0.02 mmol, 10 mol %), $K_2S_2O_8$ (0.4 mmol, 2 equiv) and DMF (2 mL). Then the tube was stirred at 50 °C (oil bath temperature) under argon atmosphere for 24 hour until complete consumption of starting material as monitored by TLC and/or GC-MS analysis. After the reaction was finished, the reaction mixture was filtered, organic layer was dried over Na_2SO_4. Then removal of the solvent, the crude product was purified by column chromatography (petroleum ether/ethyl acetate, 5 : 1) to provide the desired products **3**. An amplified experiment conducted in the presence of ACP **1a** (2.36 g, 10 mmol), 2-oxo-2-phenylacetic acid **2a** (1.5 equiv), $AgNO_3$ (10 mol %), $K_2S_2O_8$ (2 equiv) and DMF (70 mL) at 50 °C under argon atmosphere for 120 h could deliver the target product **3aa** in 61% yield (2074.9 mg).

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3aa**)*[13h]: Yield: 59.8 mg, 88%; yellow solid; mp 85.5-86.0 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.74 (d, *J* = 8.4 Hz, 3H), 7.55 (t, *J* = 7.2 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.33-7.26 (m, 5H), 7.22 (t, *J* = 8.0 Hz, 1H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.07 (s, 2H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.75 (t, *J* = 8.0 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 197.4, 155.6, 139.2, 138.6, 136.7, 135.9, 135.4, 131.3, 130.8, 129.2, 128.4, 128.0, 127.7, 126.6, 122.0, 120.5, 110.3, 69.9, 27.8, 21.7. HRMS (ESI-TOF) *m/z*: $C_{24}H_{21}O_2$ $(M + H)^+$ calcd for 341.1536, found 341.1543.

*(8-Methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ba**)*: Yield: 38.0 mg, 72%; yellow solid; mp 132.8-133.1 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.77-7.74 (m, 2H), 7.58-7.53 (m, 2H), 7.49-7.45 (m, 2H), 7.24 (t, *J* = 8.0 Hz, 1H), 6.82 (d, *J* = 7.6 Hz, 1H), 6.73 (d, *J* = 8.0 Hz, 1H), 3.77 (s, 3H), 2.90 (t, *J* = 8.0 Hz, 2H), 2.72 (t, *J* = 8.0 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 197.5, 156.5, 139.1, 138.5, 136.0, 134.7, 131.4, 130.8, 129.3, 128.1, 121.5, 120.1, 108.7, 55.4, 27.9, 22.4. HRMS (ESI-TOF) *m/z*: $C_{18}H_{17}O_2$ $(M + H)^+$ calcd for 265.1223, found 265.1229.

*(8-Nitro-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ca**)*: Yield: 29.6 mg, 53%; yellow solid; mp 84.8-85.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.83-7.81 (m, 3H), 7.64 (s, 1H), 7.61-7.58 (m, 1H), 7.53-7.49 (m, 3H), 7.40 (t, *J* = 8.0 Hz, 1H), 3.01 (t, *J* = 8.0 Hz, 2H), 2.82-2.78 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.7, 147.8, 140.8, 140.0, 137.2, 133.0, 132.5, 132.4, 129.4, 129.3, 128.5, 126.8, 123.1, 28.0, 21.3. HRMS (ESI-TOF) *m/z*: $C_{17}H_{14}NO_3$ $(M + H)^+$ calcd for 280.0968, found 280.0974.

*(7-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3da**)*: Yield: 53.0 mg, 78%; gray oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.74 (d, *J* = 7.2 Hz, 2H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.2 Hz, 2H), 7.42-7.36 (m, 5H), 7.14 (t, *J* = 8.4 Hz, 1H), 7.08 (s, 1H), 6.92-6.89 (m, 1H), 6.79-6.78 (m, 1H), 5.04 (s, 2H), 2.89 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.6, 157.4, 140.4, 138.3, 137.4, 137.0, 133.6, 131.6, 129.2, 128.6, 128.2, 127.9, 127.2, 127.0, 125.8, 121.7, 113.8, 70.2, 22.1, 20.1. HRMS (ESI-TOF) *m/z*: $C_{24}H_{21}O_2$ $(M + H)^+$ calcd for 341.1536, found 341.1545.

*(7-Methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ea**)*: Yield: 32.6 mg, 62%; yellow solid; mp 88.7-88.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.75-7.73 (m, 2H), 7.57-7.54 (m, 1H), 7.50-7.46 (m, 2H), 7.14 (d, *J* = 8.4 Hz, 1H), 7.09 (s, 1H), 6.85-6.82 (m, 1H), 6.70-6.69 (m, 1H), 3.87 (s, 3H), 2.89 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.5, 158.3, 140.4, 138.3, 137.9, 133.4, 131.7, 129.6, 129.2, 128.9, 128.2, 115.4, 113.8, 55.4, 26.6, 23.2. HRMS (ESI-TOF) *m/z*: $C_{18}H_{17}O_2$ $(M + H)^+$ calcd for 265.1223, found 265.1229.

*(5-Methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ea'**)*: Yield: 8.1 mg, 15%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 775-7.73 (m, 2H), 7.58-7.47 (m, 3H), 7.19-7.15 (m, 1H), 7.11-7.10 (m, 1H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.78 (d, *J* = 7.24 Hz, 1H), 3.87 (s, 3H), 2.94 (t, *J* = 7.6 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.5, 156.3, 140.3, 138.3, 137.4, 133.5, 131.6, 129.2, 128.2, 127.0, 125.3, 121.4, 112.2, 55.6, 22.2, 19.9. HRMS (ESI-TOF) *m/z*: $C_{18}H_{17}O_2$ $(M + H)^+$ calcd for 265.1223, found 265.1229.

*(6-Methoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3fa**)*: Yield: 44.4 mg, 84%; yellow solid; mp 62.9-63.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.72-7.70 (m, 2H), 7.57-7.53 (m, 1H), 7.49-7.45 (m, 2H), 7.13 (s, 1H), 7.08 (d, *J* = 8.4 Hz, 1H), 6.78-6.72 (m, 2H), 3.84 (s, 3H), 2.93 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.4 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.3, 161.1, 140.8, 139.7, 138.7, 134.9, 131.3, 130.4, 129.1, 128.2, 125.6, 113.8, 111.8, 55.3, 28.1, 22.4. HRMS (ESI-TOF) *m/z*: $C_{18}H_{17}O_2$ $(M + H)^+$ calcd for 265.1223, found 265.1229.

*(6-Methyl-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ga**)*: Yield: 39.7 mg, 80%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.76 (d, *J* = 8.0 Hz, 2H), 7.58-7.55 (m, 1H), 7.50-7.46 (m, 2H), 7.40 (s, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.06 (t, *J* = 8.0 Hz, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.72 (t, *J* = 8.0 Hz, 2H), 2.27 (s, 3H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.5, 138.4, 137.8, 137.4, 137.0, 136.1, 131.7, 130.9, 129.5, 129.3, 128.6, 128.2, 125.6, 28.2, 22.4, 18.9. HRMS (ESI-TOF) *m/z*: $C_{18}H_{17}O$ $(M + H)^+$ calcd for 249.1274, found 249.1279.

*Phenyl(6-phenyl-3,4-dihydronaphthalen-2-yl)methanone (**3ha**)*: Yield: 46.5 mg, 75%; yellow solid; mp 93.8-94.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.75 (d, *J* = 8.4 Hz, 2H), 7.63-7.60 (m, 2H), 7.57 (d, *J* = 7.2 Hz, 1H), 7.51-7.44 (m, 6H), 7.37 (t, *J* = 7.6 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 2H), 3.03 (t, *J* = 8.0 Hz, 2H), 2.81 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.4, 142.7, 140.4, 140.1, 138.4, 137.9, 137.3, 131.6, 129.2, 129.2, 128.8, 128.2, 127.7, 127.0, 126.6, 125.5, 27.7, 22.8. HRMS (ESI-TOF) *m/z*: $C_{23}H_{19}O$ $(M + H)^+$ calcd for 311.1430, found 311.1436.

*(8-Chloro-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ia**)*: Yield: 38.6 mg, 72%; yellow solid; mp 69.5-70.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.74-7.72 (m, 2H), 7.59-7.55 (m, 1H), 7.50-7.46 (m, 2H), 7.19-7.17 (m, 2H), 7.07 (t, *J* = 7.6 Hz, 2H), 2.93 (t, *J* = 8.0 Hz, 2H), 2.75 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.2, 139.1, 139.0, 138.1, 137.6, 135.3, 131.8, 131.0, 129.8, 129.1, 128.3, 128.0, 126.9, 27.4, 22.5. HRMS (ESI-TOF) *m/z*: $C_{17}H_{14}{}^{35}ClO$ $(M + H)^+$ calcd for 269.0728, found 269.0735.

*6-Benzoyl-7,8-dihydronaphthalene-2-carbonitrile (**3ja**)*: Yield: 34.2 mg, 66%; yellow solid; mp 98,2-99.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.75 (d, *J* = 8.4 Hz, 2H), 7.60 (t, *J* = 7.2 Hz, 1H), 7.52-7.48 (m, 4H), 7.22 (d, *J* = 8.4 Hz, 1H), 7.10 (s, 1H), 2.99 (t, *J* = 8.0 Hz, 2H), 2.79 (t, *J* = 8.4 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.8, 140.5, 138.0, 137.5, 137.3, 136.7, 132.2, 131.0, 130.7, 129.2, 128.7, 128.4, 118.7, 112.5, 27.1, 22,6. HRMS (ESI-TOF) *m/z*: $C_{18}H_{14}NO$ $(M + H)^+$ calcd for 260.1070, found 260.1076.

*(6,8-Dimethoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ka**)*: Yield: 41.7 mg, 71%; yellow solid; mp 100.9-101.1 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.74-7.71 (m, 2H), 7.55-7.51 (m, 2H), 7.48-7.44 (m, 2H), 6.38-6.37 (m, 1H), 6.28-6.27 (m, 1H), 3.84 (s, 3H), 3.75 (s, 3H), 2.90-2.85 (m, 2H), 2.71 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.3, 162.2, 158.1, 140.9, 138.9, 135.5, 133.4, 131.1, 129.2, 128.1 (2C), 115.0, 104.8, 96.2, 55.4, 28.6, 22.3. HRMS (ESI-TOF) *m/z*: $C_{19}H_{19}O_3$ $(M + H)^+$ calcd for 295.1329, found 295.1338.

*(5,8-Dimethoxy-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3la**)*: Yield: 39.4 mg, 67%; yellow solid; mp 99.8-100.1 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.76-7.74 (m, 2H), 7.54-7.53 (m, 2H), 7.49-7.45 (m, 2H), 6.85 (d, *J* = 9.2 Hz, 1H), 6.67 (d, *J* = 9.2Hz, 1H), 3.82 (s, 3H), 3.73 (s, 3H), 2.93-2.89 (m, 2H), 2.71-2.67 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.5, 151.0, 150.3, 138.5, 136.2, 134.7, 131.5, 129.3, 128.1, 126.9, 122.6, 113.1, 108.4, 56.1, 55.7, 21.7, 20.4. HRMS (ESI-TOF) *m/z*: $C_{19}H_{19}O_3$ $(M + H)^+$ calcd for 295.1329, found 295.1338.

*(8-Bromo-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ma**)*: Yield: 38.7 mg, 62%; yellow solid; mp 109.8-110.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.80-7.78 (m, 2H), 7.58-7.53 (m, 1H), 7.52-7.48 (m, 3H), 7.4-7.43 (m, 1H), 7.17-7.09 (m, 2H), 2.94 (t, *J* = 8.0 Hz, 2H), 2.7-2.72 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.0, 140.0, 138.9, 138.0, 137.9, 132.0, 131.1, 130.5, 129.4, 128.3 (2C), 127.0, 124.5, 28.4, 22.2. HRMS (ESI-TOF) *m/z*: $C_{17}H_{14}{}^{79}BrO$ $(M + H)^+$ calcd for 313.0223, found 313.0227.

*(8-Bromo-6-fluoro-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3na**)*: Yield: 49.5 mg, 75%; yellow solid; mp 68.8-69.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.79-7.77 (m, 2H), 7.60-7.57 (m, 1H), 7.52-7.48 (m, 3H), 7.21-7.18 (m, 1H), 6.94-6.91 (m, 1H), 2.93 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.8, 162.4 (d, *J* = 253.2 Hz, 1C), 141.9, 141.8, 138.2, 137.8, 137.1, 132.0, 129.3, 128.4 (t, *J* = 6.7 Hz, 1C), 124.6 (d, *J* = 10.1 Hz, 1C), 118.3 (d, *J* = 24.5 Hz, 1C), 114.5 (d, *J* = 21.4 Hz, 1C), 28.8, 21,8. ^{19}F NMR (282 MHz, $CDCl_3$): δ: -108.8 (s, 1F); HRMS (ESI-TOF) *m/z*: $C_{17}H_{13}{}^{79}Br^{19}FO$ $(M + H)^+$ calcd for 331.0128, found 331.0134.

*(8-Bromo-6-chloro-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3oa**)*: Yield: 54.7 mg, 79%; yellow solid; mp 62.7-63.1 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.79-7.77 (m, 2H), 7.61-7.57 (m, 1H), 7.52-7.46 (m, 4H), 7.18 (s, 1H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.75-2.71 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.7, 140.9, 139.1, 137.7, 136.9, 135.4, 132.1, 130.7, 130.6, 129.4, 128.3, 127.3, 124.4, 28.4, 22.0. HRMS (ESI-TOF) *m/z*: $C_{17}H_{13}{}^{79}Br^{35}ClO$ $(M + H)^+$ calcd for 346.9833, found 346.9839.

*(3,4-Dihydronaphthalen-2-yl)(phenyl)methanone (**3pa**)*: Yield: 32.8 mg, 70%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.74 (t, *J* = 8.6 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.30-7.26 (m, 1H), 7.23-7.19 (m, 2H), 7.15-7.14 (m, 2H), 2.96 (t, *J* = 8.0 Hz, 2H), 2.76 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.5, 140.4, 138.3, 137.5, 137.4, 132.5, 131.6, 129.9, 129.2, 128.8, 128.2, 127.8, 126.8, 27.5, 22.7. HRMS (ESI-TOF) *m/z*: $C_{17}H_{15}O$ $(M + H)^+$ calcd for 235.1117, found 235.1123.

*Phenyl(1-phenyl-3,4-dihydronaphthalen-2-yl)methanone (**3sa**)*: Yield: 51.5 mg, 83%; white oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.73-7.71 (m, 2H), 7.37-7.33 (m, 1H), 7.27-7.22 (m, 4H), 7.14-7.10 (m, 6H), 6.87 (d, *J* = 7.6 Hz, 1H), 3.03 (t, *J* = 7.2 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 200.2, 140.4, 137.6, 137.0, 136.9, 136.0, 135.0, 132.5, 130.2, 129.1, 128.3, 128.0, 127.9, 127.6, 127.5, 127.3, 126.5, 28.1, 27.3. HRMS (ESI-TOF) *m/z*: $C_{23}H_{19}O$ $(M + H)^+$ calcd for 311.1430, found 311.1436.

*(6-Methoxy-1-(4-methoxyphenyl)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ta**)*: Yield: 62.9 mg, 85%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.68 (d, *J* = 8.4 Hz, 2H), 7.33-7.31 (m, 1H), 7.23-7.19 (m, 2H), 7.02-7.00 (m, 2H), 6.86-6.82 (m, 2H), 6.66-6.63 (m, 3H), 3.83 (s, 3H), 3.69 (s, 3H), 2.97 (t, *J* = 7.6 Hz, 2H), 2.73-2.69 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 200.7, 159.6, 158.9, 140.9, 139.2, 137.6, 133.2, 132.1, 131.5, 130.3, 129.0, 128.9, 128.3, 127.9, 113.5, 113.3, 111.2, 55.3, 55.1, 28.7, 27.5. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_3$ $(M + H)^+$ calcd for 371.1642, found 371.1647.

*(6-Methyl-1-p-tolyl-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3ua**)*: Yield: 54.1 mg, 80%; yellow solid; mp 102.5-103.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.73-7.70 (m, 2H), 7.37-7.33 (m, 1H), 7.26-7.22 (m, 2H), 7.08 (s, 1H), 6.99 (d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.0 Hz, 3H), 6.79 (d, *J* = 8.0 Hz, 1H), 2.96 (t, *J* = 8.0 Hz, 2H), 2.71-2.67 (m, 2H), 2.35 (s, 3H), 2.20 (s, 3H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 200.4, 140.7, 138.3, 137.3, 137.2, 137.0, 134.8, 134.8, 132.5, 132.2, 130.0, 129.1, 128.6, 128.3, 127.9, 127.4, 127.1, 28.2, 27.5, 21,2, 21.1. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O$ $(M + H)^+$ calcd for 339.1743, found 339.1749.

*(6-Fluoro-1-(4-fluorophenyl)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3va**)*: Yield: 53.3 mg, 77%; yellow solid; mp 97.8-98.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.72-7.69 (m, 2H), 7.42-7.37 (m, 1H), 7.26 (t, *J* = 8.0 Hz, 2H), 7.09-7.05 (m, 2H), 7.00-6.98 (m, 1H), 6.85-6.80 (m, 4H), 3.01 (t, *J* = 7.6 Hz, 2H), 2.74-2.70 (m, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 200.0, 162.4 (d, *J* = 247.9 Hz, 1C), 162.1 (d, *J* = 246.0 Hz, 1C), 139.5 (d, *J* = 7.9 Hz, 1C), 138.7, 136.8, 135.6 (d, *J* = 2.0 Hz, 1C), 133.4 (d, *J* = 3.3 Hz, 1C), 132.7, 131.8 (d, *J* = 8.1 Hz, 1C), 130.6, 129.0, 128.9 (d, *J* = 8.5 Hz, 1C), 128.1, 115.6 (d, *J* = 21.4 Hz, 1C), 114.7 (d, *J* = 21.7 Hz, 1C), 113.2 (d, *J* = 21.1 Hz, 1C), 28.2, 27.0. ^{19}F NMR (282 MHz, $CDCl_3$): δ: -112.7 (s, 1F), -113.8 (s, 1F). HRMS (ESI-TOF) *m/z*: $C_{23}H_{17}{}^{19}F_2O$ $(M + H)^+$ calcd for 347.1242, found 347.1247.

*(6-Chloro-1-(4-chlorophenyl)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3wa**)*: Yield: 59.0 mg, 78%; yellow solid; mp 74.5-75.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.71 (d, *J* = 7.2 Hz, 2H), 7.41 (d, *J* = 7.6 Hz, 1H), 7.31-7.25 (m, 3H), 7.13-7.08 (m, 3H), 7.05-7.03 (m, 2H), 6.74 (d, *J* = 8.4

Hz, 1H), 2.99 (t, *J* = 7.6 Hz, 2H), 2.70 (t, *J* = 8.4 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 199.4, 138.5, 138.2, 136.8, 136.5, 135.6, 134.0, 133.8, 133.2, 132.9, 131.3, 129.0, 128.4, 128.3, 128.2, 127.7, 126.7, 27.8, 27.0. HRMS (ESI-TOF) *m/z*: $C_{23}H_{17}{}^{35}Cl_2O$ $(M + H)^+$ calcd for 379.0651, found 379.0656.

*(6-Bromo-1-(4-bromophenyl)-3,4-dihydronaphthalen-2-yl)(phenyl)methanone (**3xa**)*: Yield: 67.4 mg, 72%; gray oil; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.71 (d, *J* = 7.2 Hz, 2H), 7.42 (d, *J* = 7.2 Hz, 2H), 7.31-7.24 (m, 5H), 7.00-6.96 (m, 2H), 6.68 (d, *J* = 8.0 Hz, 1H), 2.99 (t, *J* = 8.0 Hz, 2H), 2.71-2.67 (m, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 199.4, 138.7, 138.2, 136.9, 136.5, 136.0, 133.6, 133.0, 131.6, 131.3, 130.5, 129.7, 129.0, 128.4, 128.3, 122.3, 122.0, 27.7, 27.0. HRMS (ESI-TOF) *m/z*: $C_{23}H_{17}{}^{79}Br_2O$ $(M + H)^+$ calcd for 468.9641, found 468.9626.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-methoxyphenyl)methanone (**3ab**)*[13h]: Yield: 64.4 mg, 87%; yellow solid; mp 116.3-117.0 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.80 (d, *J* = 8.8 Hz, 2H), 7.69 (s, 1H), 7.34-7.30 (m, 5H), 7.21 (t, *J* = 8.0 Hz, 1H), 6.94 (d, *J* = 8.8 Hz, 2H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 1H), 5.09 (s, 2H), 3.89 (s, 3H), 2.91 (t, *J* = 7.6 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 196.2, 162.4, 155.5, 139.1, 136.9, 136.2, 133.8, 131,6, 131.0, 130.5, 128.5, 127.8, 126.7, 122.2, 120.5, 113.3, 110.3, 70.0, 55.4, 27.9, 22.3. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_3$ $(M + H)^+$ calcd for 371.1642, found 371.1655.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-(methylthio)phenyl)methanone (**3ac**)*: Yield: 61.0 mg, 79%; white solid; mp 119.8-120.4 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.72-7.70 (m, 3H), 7.37-7.28 (m, 7H), 7.22 (t, *J* = 7.6 Hz, 1H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 1H), 5.09 (s, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H), 2.54 (s, 3H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 196.4, 155.6, 143.6, 139.1, 136.8, 136.0, 134.7, 130.7, 129.9, 128.7, 128.5, 127.8, 126.7, 124.8, 122.0, 120.5, 110.3, 69.9, 27.9, 22.0, 14.9. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_2S$ $(M + H)^+$ calcd for 387.1413, found 387.1419.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(p-tolyl)methanone (**3ad**)*[13h]: Yield: 58.1 mg, 82%; yellow solid; mp 106.7-108.0 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.72 (s, 1H), 7.67 (d, *J* = 8.0 Hz,

2H), 7.31 (s, 5H), 7.26-7.23 (m, 2H), 7.20 (d, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 7.6 Hz, 1H), 6.78 (d, *J* = 8.0 Hz, 1H), 5.08 (s, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H), 2.45 (s, 3H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.1, 155.6, 141.9, 139.1, 136.9, 136.1, 135.8, 134.7, 130.6, 129.5, 128.7, 128.4, 127.7, 126.7, 122.2, 120.5, 110.4, 69.9, 27.9, 22.0, 21.6. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_2$ $(M + H)^+$ calcd for 355.1693, found 355.1699.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-isopropylphenyl)methanone ***(3ae)***: Yield: 66.5 mg, 87%; mp 69.2-70.3 ºC (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.72 (t, *J* = 8.4 Hz, 3H), 7.34-7.29 (m, 7H), 7.23 (t, *J* = 8.0 Hz, 1H), 6.85 (d, *J* = 7.6 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 1H), 5.08 (s, 2H), 3.02-2.96 (m, 1H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H), 1.30 (d, *J* = 7.2 Hz, 6H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.0, 155.6, 152.7, 139.1, 136.8, 136.1, 134.7, 130.6, 129.6, 128.5, 128.4, 127.8, 126.8, 126.1, 122.1, 120.5, 110.2, 70.0, 34.2, 27.9, 23.8, 21.9. HRMS (ESI-TOF) *m/z*: $C_{27}H_{27}O_2$ $(M + H)^+$ calcd for 383.2006, found 383.2011.

[1,1'-Biphenyl]-4-yl(8-(benzyloxy)-3,4-dihydronaphthalen-2-yl)methanone ***(3af)***: Yield: 66.6 mg, 80%; yellow solid; 113.5-114.3 ºC (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.85-7.84 (m, 2H), 7.83-7.82 (m, 1H), 7.68-7.64 (m, 4H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.43 (d, *J* = 7.2 Hz, 1H), 7.32-7.29 (m, 2H), 7.25-7.21 (m, 4H), 6.65 (d, *J* = 7.2 Hz, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.08 (s, 2H), 2.93 (t, *J* = 8.0 Hz, 2H), 2.77 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.9, 155.6, 144.1, 140.2, 139.2, 137.3, 136.8, 136.1, 135.2, 130.8, 129.9, 128.9, 128.9, 128.5, 127.9, 127.8, 127.2, 126.7, 122.1, 120.5, 110.4, 70.0, 27.9, 21.9. HRMS (ESI-TOF) *m/z*: $C_{30}H_{25}O_2$ $(M + H)^+$ calcd for 417.1849, found 417.1855.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-fluorophenyl)methanone ***(3ag)***: Yield: 55.1 mg, 77%; white solid; mp 105.8-106.2 ºC (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.79-7.76 (m, 2H), 7.68 (s, 1H), 7.35-7.29 (m, 5H), 7.23 (t, *J* = 8.4 Hz, 1H), 7.13 (t, *J* = 8.8 Hz, 2H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.08 (s, 2H), 2.91 (t, *J* = 7.6 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 195.9, 164.7 (d, *J* = 250.4 Hz, 1C), 155.6, 139.1, 136.7, 135.8, 135.2, 131.7, 131.6, 130.9, 128.5 (d, *J* = 6.9 Hz, 1C), 127.9 (d, *J* = 3.2 HZ, 1C), 126.7, 121.9, 120.5, 115.1 (d, *J* =

21.6 Hz, 1C), 110.3, 69.9, 27.8, 21.9. ^{19}F NMR (282 MHz, $CDCl_3$) δ: -108.0 (s, 1F). HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{19}FO_2$ $(M + H)^+$ calcd for 359.1442, found 359.1447.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-chlorophenyl)methanone ***(3ah)***[13h]: Yield: 56.1 mg, 75%; yellow solid; mp 150.2-151.3 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.70-7.67 (m, 3H), 7.43 (d, *J* = 8.4 Hz, 2H), 7.37-7.36 (m, 3H), 7.34-7.28 (m, 2H), 7.23 (d, *J* = 8.0 Hz, 1H), 6.85 (d, *J* = 7.6 Hz, 1H), 6.80 (d, *J* = 8.0 Hz, 1H), 5.08 (s, 2H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.1, 155.7, 139.2, 137.5, 136.9, 136.7, 135.7, 131.1, 130.6, 128.5 (2C), 128.3, 127.9, 126.6, 121.9, 120.5, 110.3, 69.9, 27.8, 21.7. HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{35}ClO_2$ $(M + H)^+$ calcd for 375.1146, found 375.1153.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-bromophenyl)methanone ***(3ai)***: Yield: 55.2 mg, 66%; yellow solid; mp 146.7-147.3 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.69 (s, 1H), 7.62-7.57 (m, 4H), 7.36-7.33 (m, 3H), 7.31-7.29 (m, 2H), 7.24 (t, *J* = 8.0 Hz, 1H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 1H), 5.08 (s, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 196.2, 155.7, 139.2, 137.4, 136.7, 135.9, 135.7, 131.3, 131.1, 130.8, 128.5, 127.9, 126.6, 126.0, 121.8, 120.5, 110.3, 69.9, 27.7, 21,6. HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{79}BrO_2$ $(M + H)^+$ calcd for 419.0641, found 419.0647.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(4-(trifluoromethyl)phenyl)methanone ***(3aj)***[13h]: Yield: 49.8 mg, 61%; yellow solid; mp 128.9-129.7 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.80 (d, *J* = 8.0 Hz, 2H), 7.70-7.68 (m, 3H), 7.32-7.29 (m, 3H), 7.28-7.23 (m, 3H), 6.85 (d, *J* = 7.2 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 1H), 5.05 (s, 2H), 2.93 (t, *J* = 8.0 Hz, 2H), 2.75 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 195.9, 155.8, 141.9, 139.2, 136.7, 136.5, 135.5, 132.6 (q, *J* = 32.2 Hz, 1C), 131.4, 129.3, 128.4, 128.0, 126.6, 125.0 (q, *J* = 3.8 Hz, 1C), 123.8 (d, *J* = 270.8 Hz, 1C), 121.7, 120.6, 110.3, 70.0, 27.7, 21.3. ^{19}F NMR (282 MHz, $CDCl_3$) δ: -62.7 (s, 3F). HRMS (ESI-TOF) *m/z*: $C_{25}H_{20}{}^{19}F_3O_2$ $(M + H)^+$ calcd for 409.1410, found 409.1418.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(3-methoxyphenyl)methanone ***(3al)***[13h]: Yield: 60.7 mg, 82%; yellow solid; 125.1-126.2 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.76 (s, 1H), 7.35-7.26 (m, 8H), 7.22 (t, *J* = 7.6 Hz, 1H), 7.11-7.10 (m, 1H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.08 (s, 2H), 3.81 (s, 3H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.1, 159.3, 155.6, 139.9, 139.2, 136.7, 135.9, 135.4, 130.8, 129.0, 128.5, 127.8, 126.6, 122.0, 121.8, 120.5, 117.9, 113.4, 110.3, 69.9, 55.3, 27.8, 21.7. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_3$ $(M + H)^+$ calcd for 371.1642, found 371.1655.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(m-tolyl)methanone ***(3am)***: Yield: 53.8 mg, 76%; yellow solid; 67.8-68.3 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.73 (s, 1H), 7.55-7.52 (m, 2H), 7.35-7.28 (m, 7H), 7.22 (t, *J* = 8.0 Hz, 1H), 6.84 (d, *J* = 7.2 Hz,1H), 6.79 (d, *J* = 8.0 Hz, 1H), 5.07 (s, 2H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.74 (t, *J* = 8.0 Hz, 2H), 2.38 (s, 3H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.7, 155.7, 139.3, 138.7, 138.0, 136.9, 136.1, 135.3, 132.1, 130.8, 129.8, 128.5, 127.9, 127.8, 126.7, 126.5, 122.1, 120.6, 110.3, 69.9, 27.9, 21.8, 21.4. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_2$ $(M + H)^+$ calcd for 355.1693, found 355.1699.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(3-chlorophenyl)methanone ***(3an)***: Yield: 52.4 mg, 70%; yellow solid; mp 126.5-127.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.73-7.71 (m, 2H), 7.60 (d, *J* = 7.6 Hz, 1H), 7.54-7.51 (m, 1H), 7.40-7.30 (m, 6H), 7.24 (t, *J* = 7.2 Hz, 1H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 1H), 5.08 (s, 2H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 195.7, 155.8, 140.3, 139.2, 136.7, 135.9, 135.6, 134.2, 131.2, 131.1, 129.4, 129.2, 128.5, 127.9, 127.3, 126.7, 121.8, 120.5, 110.3, 70.0, 27.8, 21.7. HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{35}ClO_2$ $(M + H)^+$ calcd for 375.1146, found 375.1153.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(o-tolyl)methanone ***(3ao)***: Yield: 52.4 mg, 74%; yellow solid; mp 86.2-87.0 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.57 (s, 1H), 7.39-7.35 (m, 1H), 7.32-7.29 (m, 4H), 7.26-7.22 (m, 3H), 7.20-7.18 (m, 2H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 5.02 (s, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.75 (t, *J* = 8.0 Hz, 2H), 2.32 (s, 3H). ^{13}C{1H}NMR (100

MHz, $CDCl_3$) δ: 199.5, 155.6, 139.4, 139.4, 137.0, 136.8, 136.7, 135.7, 131.1, 130.6, 129.2, 128.4, 127.7, 127.6, 126.3, 125.0, 122.1, 120.6, 110.3, 69.7, 27.8, 20.4, 19.7. HRMS (ESI-TOF) *m/z*: $C_{25}H_{23}O_2$ $(M + H)^+$ calcd for 355.1693, found 355.1699.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(2-fluorophenyl)methanone (**3ap**)*: Yield: 50.8 mg, 71%; yellow oil; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.69 (s, 1H), 7.48-7.44 (m, 2H), 7.31-7.29 (m, 3H), 7.26-7.21 (m, 4H), 7.12 (d, *J* = 9.2 Hz, 1H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.78 (d, *J* = 8.4 Hz, 1H), 5.05 (s, 2H), 2.91 (t, *J* = 7.6 Hz, 2H), 2.76 (t, *J* = 8.0 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 193.8, 159.5 (d, *J* = 248.4 Hz, 1C), 155.7, 139.5, 136.8 (d, *J* = 12.0 Hz, 1C), 136.6, 131.7 (d, *J* = 8.0 Hz, 1C), 131.3, 130.1 (d, *J* = 3.2 Hz, 1C), 128.4, 127.8, 127.7, 127.6, 126,5, 123.9 (d, *J* = 3.5 Hz, 1C), 122.0, 120.6, 116.0 (d, *J* = 21.8 Hz, 1C), 110.3, 69.8, 27.7, 20.6; ^{19}F NMR (282 MHz, $CDCl_3$): δ: -113.4 (s, 1F). HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{19}FO_2$ $(M + H)^+$ calcd for 359.1442, found 359.1447.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(2-chlorophenyl)methanone (**3aq**)*: Yield: 46.4 mg, 62%; white solid; mp 125.6-126.0 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.55 (s, 1H), 7.45-7.35 (m, 4H), 7.34-7.29 (m, 3H), 7.25-7.19 (m, 3H), 6.83 (d, *J* = 7.6 Hz, 1H), 6.76 (d, *J* = 8.4 Hz, 1H), 5.01 (s, 2H), 2.91 (t, *J* = 7.6 Hz, 2H), 2.76 (t, *J* = 8.0 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, CDCl3) δ: 195.8, 155.7, 139.5, 139.1, 137.4, 136.7, 136.2, 131.4, 131.1, 130.3, 129.8, 128.8, 128.4, 127.6, 126.3, 126.3, 121.9, 120.6, 110.3, 69.8, 27.6, 20.2. HRMS (ESI-TOF) *m/z*: $C_{24}H_{20}{}^{35}ClO_2$ $(M + H)^+$ calcd for 375.1146, found 375.1153.

*(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(3,4-dichlorophenyl)methanone (**3ar**)*: Yield: 43.3 mg, 58%; yellow solid; mp 78.6-79.2 °C (uncorrected); ^1H NMR (400 MHz, $CDCl_3$) δ: 7.84-7.83 (m, 1H), 7.68 (s, 1H), 7.57-7.55 (m, 1H), 7.51 (d, *J* = 8.4 Hz, 1H), 7.36-7.27 (m, 5H), 7.24 (d, *J* = 7.6 Hz, 1H), 6.86-6.80 (m, 2H), 5.09 (s, 2H), 2.92 (t, *J* = 8.0 Hz, 2H), 2.72 (t, *J* = 8.4 Hz, 2H). $^{13}C\{1H\}$NMR (100 MHz, $CDCl_3$) δ: 198.8, 155.7, 134.9, 137.5, 137.1, 136.6, 133.6, 131.2, 130.0, 128.3, 128.3, 127.6, 126.8, 126.4, 126.2, 125.6, 124.3, 120.5, 110.3, 69.7, 27.9, 20.8. HRMS (ESI-TOF) *m/z*: $C_{24}H_{19}{}^{35}Cl_2O_2$ $(M + H)^+$ calcd for 409.0757, found 409.0764.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(naphthalen-1-yl)methanone (***3as)*** **:** Yield: 51.5 mg, 66%; yellow solid; mp 87.0-87.5 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.03-8.01 (m, 1H), 7.98 (d, *J* = 8.0 Hz, 1H), 7.93-7.91 (m, 1H), 7.65 (s, 1H), 7.69-7.57 (m, 1H), 7.54-7.49 (m, 3H), 7.24-7.19 (m, 4H), 7.03 (d, *J* = 7.2 Hz, 2H), 6.84 (d, *J* = 7.2 Hz, 1H), 6.73 (d, *J* = 8.4 Hz, 1H), 4.94 (s, 2H), 2.96 (t, *J* = 7.6 Hz, 2H), 2.87 (t, *J* = 7.6 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 198.7, 155.7, 139.4, 137.6, 137.2, 137.1, 136.6, 133.6, 131.2, 131.0, 130.0, 128.4, 128.3, 127.6, 126.8, 126.4 (2C), 126.2, 126.2, 125.7, 124.3, 122.1, 120.5, 110.4, 69.7, 27.9, 20.8. HRMS (ESI-TOF) *m/z*: $C_{28}H_{23}O_2$ $(M + H)^+$ calcd for 391.1693, found 391.1698.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(naphthalen-2-yl)methanone ***(3at)*****:** Yield: 47.6 mg, 61%; yellow solid; mp 87.0-87.5 °C (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.28 (s, 1H), 7.93-7.92 (m, 3H), 7.86 (d, *J* = 8.4 Hz, 1H), 7.81 (s, 1H), 7.62 (t, *J* = 7.2 Hz, 1H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.24-7.16 (m, 3H), 7.07 (t, *J* = 7.6 Hz, 2H), 6.87 (d, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 8.4 Hz, 1H), 5.04 (s, 3H), 2.97 (t, *J* = 8.0 Hz, 2H), 2.81 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 197.3, 155.6, 139.2, 136.6, 136.2, 135.8, 135.4, 134.8, 132.3, 130.8, 130.2, 129.2, 128.4, 128.1, 127.7 127.7, 127.6, 126.6, 126.5, 125.8, 122.1, 120.5, 110.3, 69.9, 27.9, 21.9. HRMS (ESI-TOF) *m/z*: $C_{28}H_{23}O_2$ $(M + H)^+$ calcd for 391.1693, found 391.1698.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(thiophen-2-yl)methanone ***(3au)***[13h]: Yield: 36.0 mg, 52%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.98 (s, 1H), 7.71-7.70 (m, 1H), 7.64-7.63 (m, 1H), 7.41-7.31 (m, 5H), 7.22 (t, *J* = 8.0 Hz, 1H), 7.13-7.12 (m, 1H), 6.83 (t, *J* = 8.8 Hz, 2H), 5.13 (s, 2H), 2.91 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 188.3, 155.6, 143.6, 139.0, 136.8, 136.3, 132.7, 132.7, 132.6, 130.6, 128.5, 127.9, 127.5, 126.9, 122.0, 120.5, 110.3, 70.1, 27.8, 22.5. HRMS (ESI-TOF) *m/z*: $C_{22}H_{19}O_2S$ $(M + H)^+$ calcd for 347.1100, found 347.1107.

(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)(furan-2-yl)methanone ***(3av)***: Yield: 33.0 mg, 50%; yellow oil; ^{1}H NMR (400 MHz, CDCl3) δ: 8.18 (s, 1H), 7.62 (s, 1H), 7.45-7.40 (m, 2H), 7.39-7.33 (m, 3H), 7.23 (t, *J* = 8.0 Hz, 1H), 7.19-7.18 (m, 1H), 6.85-6.81 (m, 2H), 6.54-6.53 (m, 1H), 5.14 (s, 2H),

2.89 (t, *J* = 8.0 Hz, 2H), 2.72 (t, *J* = 8.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 182.8, 155.8, 152.4, 146.1, 139.2, 136.9, 135.8, 132.8, 130.7, 128.5, 127.9, 126.9, 122.1, 120.5, 118.5, 111.7, 110.3, 70.2, 27.8, 22.0. HRMS (ESI-TOF) *m/z*: $C_{22}H_{19}O_3$ $(M + H)^+$ calcd for 331.1329, found 331.1334.

*1-(8-(Benzyloxy)-3,4-dihydronaphthalen-2-yl)ethanone (**3aw**)*: Yield: 31.1 mg, 56%; gray solid; mp 74.8-75.1 ºC (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.92 (s, 1H), 7.46-7.39 (m, 4H), 7.37-7.33 (m, 1H), 7.21 (t, *J* = 8.0 Hz, 1H), 6.80 (d, *J* = 8.4 Hz, 2H), 5.16 (s, 2H), 2.80 (t, *J* = 8.4 Hz, 2H), 2.56 (t, *J* = 8.0 Hz, 2H), 2.44 (s, 3H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 198.9, 155.6, 139.3, 137.0, 136.8, 131.7, 130.7, 128.6, 128.0, 127.1, 121.9, 120.5, 110.3, 70.3, 27.8, 25.3, 20.4. HRMS (ESI-TOF) *m/z*: $C_{19}H_{19}O_2$ $(M + H)^+$ calcd for 279.1380, found 279.1385.

*1,3,3-Triphenylprop-2-en-1-one (**5**)*: Yield: 26.1 mg, 46%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.91 (d, *J* = 7.2 Hz, 2H), 7.48 (t, *J* = 7.2 Hz, 1H), 7.42-7.36 (m, 7H), 7.28-7.24 (m, 3H), 7.19-7.17 (m, 2H), 7.12 (s, 1H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 192.7, 154.8, 141.3, 138.9, 138.1, 132.7, 129.7, 129.3, 128.7, 128.6, 128.4, 128.3, 128.0, 123.9. HRMS (ESI-TOF) *m/z*: $C_{21}H_{17}O$ $(M + H)^+$ calcd for 285.1274, found 285.1279.

*5-(Benzyloxy)-3-(1-(4-methoxyphenyl)vinyl)-1,2-dihydronaphthalene (**6**)*: Yield: 48.6 mg, 66%; white solid; mp 103.5-104.9 ºC (uncorrected); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.33-7.29 (m, 5H), 7.29-7.26 (m, 2H), 7.06 (d, *J* = 8.0 Hz, 1H), 6.91-6.89 (m, 3H), 6.78 (d, *J* = 7.6 Hz, 1H), 6.73 (d, *J* = 8.0 Hz, 1H), 5.39 (s, 1H), 5.15 (s, 1H), 5.00 (s, 2H), 3.84 (s, 3H), 2.89 (t, *J* = 8.0 Hz, 2H), 2.55 (t, *J* = 8.0 Hz, 2H). ^{13}C{1H}NMR (100 MHz, $CDCl_3$) δ: 158.9, 154.2, 150.3, 138.3, 137.3, 136.9, 133.9, 130.0, 128.3, 127.5 (2C), 126.6, 124.0, 121.7, 120.2, 113.3, 112.0, 110.3, 69.9, 55.2, 28.4, 24.8. HRMS (ESI-TOF) *m/z*: $C_{26}H_{25}O_2$ $(M + H)^+$ calcd for 369.1849, found 369.1857.

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Supporting Information Available: The copies of spectra. This material is available free of charge via the Internet at http://pubs.acs.org.

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