Advanced Synthesis & Catalysis

Accepted Article

Title: Construction of Halofunctionalized Indenes via a Cascade Prins-Nazarov Cyclization Promoted by Dual Roles of BX3

Authors: Sabera Sultana and Yong Rok Lee

To be cited as: *Adv. Synth. Catal.* 10.1002/adsc.201901266

Link to VoR: http://dx.doi.org/10.1002/adsc.201901266

10.1002/adsc.201901266

FULL PAPER

DOI: 10.1002/adsc.201((will be filled in by the editorial staff))

Construction of Halofunctionalized Indenes via a Cascade Prins-Nazarov Cyclization Promoted by Dual Roles of BX_3

Sabera Sultana[a] and Yong Rok Lee[a]*

[a] School of Chemical Engineering, Yeungnam University, Gyeongsan 38541, Republic of Korea. E-mail: yrlee@yu.ac.kr; Fax: +82-53-810-4631; Tel: +82-53-810-2529

Received: ((will be filled in by the editorial staff))

Supporting information for this article is available on the WWW under http://dx.doi.org/10.1002/adsc.201######.((Please delete if not appropriate))

Abstract. Halofunctionalization of various unactivated arylalkynes to the corresponding *1H*-indenes in the presence of a particular class of carboxaldehydes and boron trihalides (BX_3, X = F, Cl, Br, I) is described. A diverse array of halofunctionalized indenes substituted with a heterocycle has been synthesized regioselectively with BX_3 as a promotor for the carbocyclization and a source of X^- for halogenation. This reaction proceeds via a formal halogenative [4+1] cycloaddition between arylalkynes and carboxaldehydes promoted by boron trihalides to generate halofunctionalized indenes. The usefulness of the halofunctionalized indenes was demonstrated by their conversion to other derivatives via coupling, nucleophilic substitution, and oxidation.

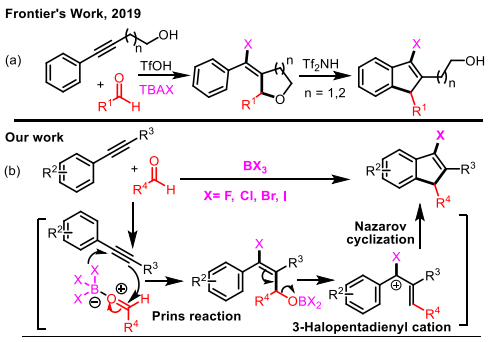
Keywords: boron reagents; halogenation; carbaldehydes; haloindenes; Nazarov cyclization

Introduction

Indenes are an important class of compounds found in many natural products and pharmaceuticals.[1] Moreover, they are widely used as building blocks for the synthesis of metallocene complexes and functional materials.[2] Owing to the importance and synthetic utility of indenes, many approaches based on intra-[3] and intermolecular[4] cyclization reactions have been reported for their synthesis. The general approaches for preparing haloindenes include gold(I)-catalyzed intramolecular cyclization of iodo-functionalized alkynes,[5] iodonium-promoted cyclization of arylethynylmalonates,[6] palladium-catalyzed tandem reaction of 2-alkenylphenylacetylenes with CuX_2 (X = Cl, Br),[7] and reactions of *o*-(alkynyl)styrenes with NXS (X = I, Br).[8] However, there is no report on any direct approach for the synthesis of fluorine-containing indenes on the cyclopentadiene moiety.

In the past decades, fluorine-containing organic molecules were widely used in pharmaceuticals, agrochemicals, and functional materials.[9] In this regard, significant efforts have been made to develop new methods for the formation of C-F bonds under transition-metal-catalyzed or metal-free conditions.[10] A number of nucleophilic or electrophilic fluorinating reagents including HF complex, *N*-fluoropyridium salts, NFSI, and Selectfluor, have been used.[10,11] However, due to their poor solubility, selectivity, and stability, there is a strong demand for milder and more facile fluorinating reagents.

Boron trifluoride etherate ($BF_3{\cdot}OEt_2$) has been widely used as a mild Lewis acid in synthetic organic chemistry.[12] It has also been employed as nucleophilic fluoride source as it is inexpensive, effective, and easy to handle.[13] $BF_3{\cdot}OEt_2$-promoted ring opening reactions of epoxides or aziridines to produce fluorinated compounds have been reported[13a] however, $BF_3{\cdot}OEt_2$-promoted Prins reactions of arylalkynes with carboxaldehydes for the synthesis of fluoroindenes have not yet been developed. We envisioned that $BF_3{\cdot}OEt_2$ can act as a bifunctional reagent as a Lewis acid and a source of F^- for the construction of fluoroindenes via the cascade Prins and Nazarov cyclization starting from readily available arylalkynes and carboxaldehydes.



Scheme 1. Synthetic strategies to haloindenes via a cascade Prins–Nazarov cyclization.

The Nazarov reaction is a powerful method for the generation of cyclopentenones and heterocycles.[14] Recently, the Frontier's group reported a two-step protocol for haloindene formation starting from alkynols and aldehydes using

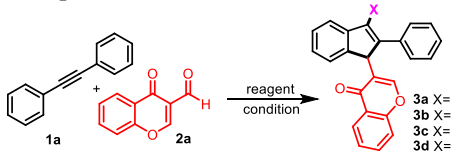
10.1002/adsc.201901266

tetrabutylammoniumhalide as a source of halogenating agent in the cyclic ether formation followed by halo-Nazarov cyclization (Scheme 1a).[15] Herein, we report $BF_3{\cdot}OEt_2$ and other BX_3-promoted cascade reactions of arylalkynes and carboxaldehydes for the direct synthesis of diversely functionalized haloindenes (X = F, Cl, Br, I) bearing heterocycles on the cyclopentene ring (Scheme 1b).

Results and Discussion

Our study commenced with the reaction of 1,2-diphenylethyne (**1a**) with 3-formylchromone (**2a**) in the presence of different halogenating reagents and solvents (Table 1). The initial attempt with $AgBF_4$ (1.0 equiv) and CsF (1.0 equiv) was unsuccessful, and the desired product **3a** was not obtained (entries 1-2). When the reaction was carried out using $BF_3{\cdot}OEt_2$ (0.5-2.0 equiv) at room temperature, **3a** was obtained in 48-65% yield (entries 3-5). Elevating the temperature in refluxing dichloromethane did not increase the yield (entry 6), and changing the solvents to THF, 1,4-dioxane, and acetonitrile completely shut down the reaction (entries 7-9). To prepare chloroindene **3b** and bromoindene **3c**, several chloro and brominating reagents were also screened (entries 10-21). Among these only BCl_3 and BBr_3 provided **3b** and **3c** in varying yields depending on the stoichiometry of the reagents. In cases of further reactions with CuI_2, NIS, and BI_3 (1.0–2.0 equiv), only BI_3 generated **3d** (entries 22-25) in 40% yield. The structure of compound **3a** was assigned by ^1H NMR spectrum, which shows a characteristic signal of a vinylic proton on the cyclopentadiene ring at 5.61 ppm as a broad singlet and a signal for the vinyl proton on the chromone ring at 7.37 ppm as a singlet.

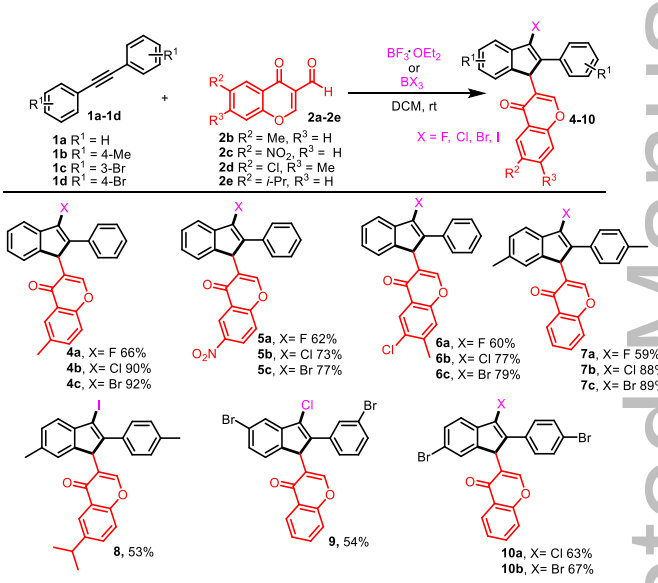
Table 1. Optimization of the reaction conditions.[a]



Entry	Reagent (equiv.)	Solvent	Temp	Time (h)	X	Yield (%)[b]
1	$AgBF_4$ (1.0)	DCM	rt	12	F	0
2	CsF (1.0)	DCM	rt	12	F	0
3	$BF_3{\cdot}OEt_2$ (1.0)	DCM	rt	3	F	65
4	$BF_3{\cdot}OEt_2$ (0.5)	DCM	rt	12	F	48
5	$BF_3{\cdot}OEt_2$ (2.0)	DCM	rt	12	F	62
6	$BF_3{\cdot}OEt_2$ (1.0)	DCM	reflux	12	F	64
7	$BF_3{\cdot}OEt_2$ (1.0)	THF	rt	12	F	0
8	$BF_3{\cdot}OEt_2$ (1.0)	1,4-dioxane	rt	12	F	0
9	$BF_3{\cdot}OEt_2$ (1.0)	CH_3CN	rt	12	F	0
10	$CuCl_2$ (2.0)	DCM	rt	12	Cl	0
11	$ZnCl_2$ (2.0)	DCM	rt	12	Cl	0
12	NCS (2.0)	DCM	rt	12	Cl	0
13	BCl_3 (1.0)	DCM	rt	12	Cl	15
14	BCl_3 (2.0)	DCM	rt	6	Cl	52
15[c]	BCl_3 (3.0)	DCM	rt	--	Cl	91
16	$CuBr_2$ (2.0)	DCM	rt	12	Br	0
17	NBS (2.0)	DCM	rt	12	Br	0
18	PBr_3 (2.0)	DCM	rt	12	Br	0
19	BBr_3 (1.0)	DCM	rt	12	Br	20
20	BBr_3 (2.0)	DCM	rt	3	Br	50
21[c]	BBr_3 (3.0)	DCM	rt	--	Br	92
22	CuI_2 (2.0)	DCM	rt	12	I	0
23	NIS (2.0)	DCM	rt	12	I	0
24	BI_3 (1.0)	DCM	rt	12	I	40
25	BI_3 (2.0)	DCM	rt	12	I	40

[a]Reaction conditions: **1a** (0.5 mmol), **2a** (0.5 mmol) in solvent (1 mL). [b]Isolated yields. [c]Reaction was completed during the addition of reagents.

With the optimized conditions in hand, we further explored the generality of this cascade reaction employing different symmetric arylethynes and diverse 3-formylchromones (Scheme 2). To our delight, various electron-donating and -withdrawing groups were well tolerated under the standard reaction conditions. For example, reaction of **1a** with 3-formylchromones **2b-2d** bearing 6-methyl, 6-NO_2, and both 6-Cl and 7-Me groups on the benzene ring in the presence of halogenating reagents BX_3 (X = F, Cl, Br) smoothly afforded the corresponding halogenated products **4a-c**, **5a-c**, and **6a-c** with good yields. In the ^{19}F NMR of **4a**, a signal appeared at -129.9 ppm due to the formation of C(sp^2)–F bond. Further reactions of symmetric 1,2-diarylethylenes **1b-1d** bearing an electron-donating group such as 4-Me and electron-withdrawing groups (4-Br, 3-Br) with **2a** and **2e** afforded **7a-c**, iodo substituted indene **8, 9** and **10a-b** in 59-89%, 53%, 54% and 63-67% yields, respectively.

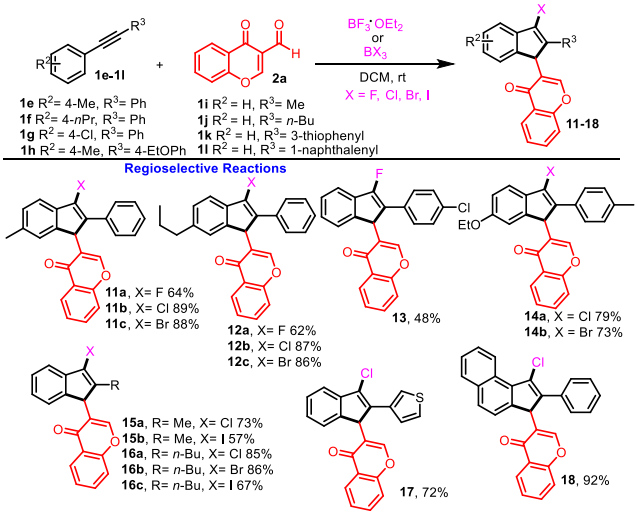


Scheme 2. Substrate scope of symmetric arylethynes and 3-formylchromones. [a]Reaction conditions: **1** (0.5 mmol), **2** (0.5 mmol), DCM (1 mL), $BF_3{\cdot}OEt_2$ (1.0 equiv.), 3 h; For BCl_3 or BBr_3 (3.0 equiv.), reaction was completed during the addition; BI_3 (1.0 equiv.), 12 h. All the yields are isolated yield.

On the other hand, the reaction of monosubstituted 1,2-arylphenylethynes **1e-1f** bearing electron-donating groups (4-Me and 4-*n*-Pr) with **2a** in the presence of BX_3 (X = F, Cl, Br) regioselectively provided the halogenated indenes **11a-c** (64-89%) and **12a-c** (62-87%). However, treatment of **1g** bearing an electron-withdrawing group (4-Cl) with **2a** provided **13** in 48% yield (Scheme 3). Importantly, only one of the two possible regioisomers was selectively generated depending on the substituent type. Electron-rich diarylalkynes provided products bearing substituents on the indene moiety, whereas

10.1002/adsc.201901266

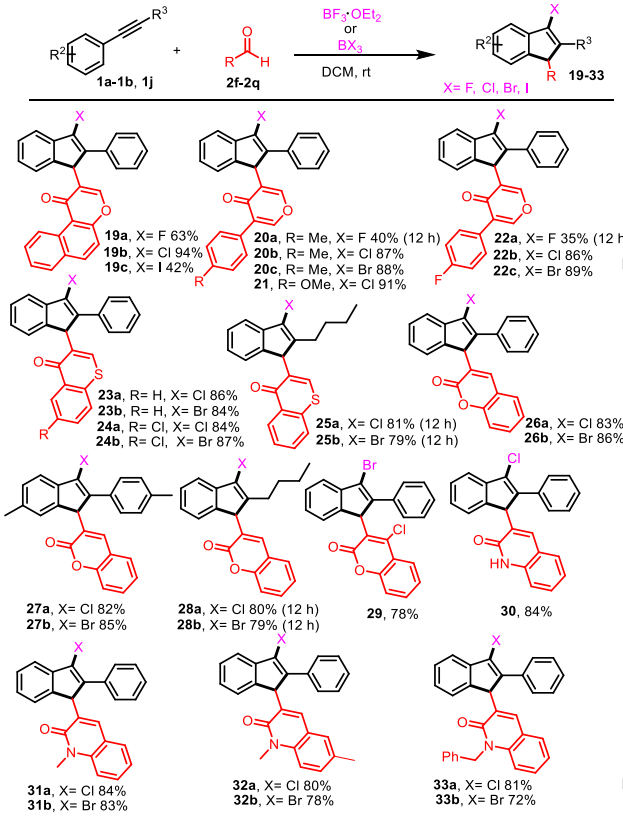
substrates with an electron-withdrawing group gave the corresponding product bearing substituents on the benzene ring at the indene moiety. Similarly, the reaction of nonsymmetric disubstituted 1,2-arylphenylethyne **1h** with **2a** provided halogenated indenes **14a-b** in 79 and 73% yields, respectively. Further reactions of arylalkylacetylenes **1i** or **1j** with **2a** provided the corresponding products **15-16** in 57-86% yields. Reactions of 3-(phenylethynyl)thiophene (**1k)** and 1-(phenylethynyl)naphthalene (**1l)** provided **17** and **18** in 72 and 92% yields, respectively. The regiochemistry of the indenes was determined by their ^{1}H NMR analysis. Further structural confirmation of these compounds was realized by a single crystal X-ray crystallographic analysis of structurally related compound **12c**.



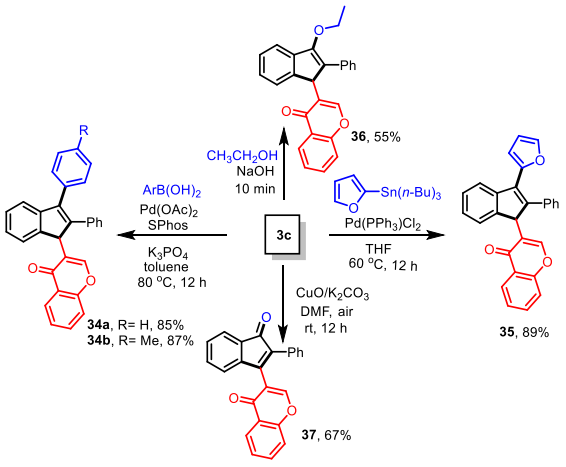
Scheme 3. Substrate scope of nonsymmetric arylethynes. [a]Reaction conditions: **1** (0.5 mmol), **2** (0.5 mmol), DCM (1 mL), BF_3·OEt_2 (1.0 equiv.), 3 h; For BCl_3 or BBr_3 (3.0 equiv.), reaction was completed during the addition; BI_3 (1.0 equiv.), 12 h. All the yields are isolated yield.

Having established the general applicability of this protocol, we were intrigued by the possibility of using other carboxaldehydes such as 1-oxo-1*H*-benzo[*f*]chromene-2-carbaldehyde (**2f)**, 4-oxo-5-phenyl-4*H*-pyran-3-carbaldehydes **2g-2i**, 4-oxo-4*H*-thiochromene-3-carbaldehydes **2j-2k**, 2-oxo-2*H*-chromene-3-carbaldehydes **2l-2m** and 2-oxo-1,2-dihydroquinoline-3-carbaldehydes **2n-2q** (Scheme 4). Gratifyingly, the reactions of **1a, 1b,** and **1j** with **2f-2q** in the presence of boron-based halogenating reagents provided **19-33** in 35-94% yields. Notably, the reactions of many substituted alkynes in the presence of BF_3·OEt_2 were relatively selective and provided a lower yield of products compared to BCl_3 and BBr_3, probably due to higher bond strength of B-F than that of B-Cl and B-Br of other halogens.[16] The use of phenylacetylene as a terminal alkyne under standard reaction conditions failed to provide the desired product, instead intractable mixtures were obtained.

Further transformations of synthetic compound **3c** were next investigated at the C-3 position (Scheme 5). The palladium-catalyzed cross-coupling and Stille coupling of **3c** afforded aryl-substituted products **34a-b** (85 and 87%) and functionalized product **35** in 89% yield. Interestingly, **3c** could undergo nucleophilic substitution with ethanol in NaOH to afford the corresponding ether product **36** in 55% yield. Oxidation of **3c** with CuO afforded **37** in 67% yield.

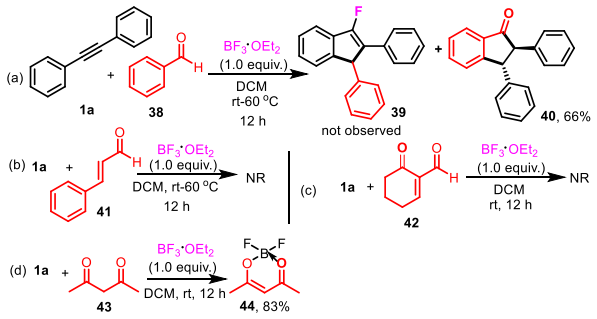


Scheme 4. Substrate scope of carboxaldehydes for the formation of 3-haloindenes. [a]Reaction conditions: **1** (0.5 mmol), **2** (0.5 mmol), DCM (1 mL), BF_3·OEt_2 (1.0 equiv.), 3 h; For BCl_3 or BBr_3 (3.0 equiv.), reaction was completed during the addition; BI_3 (1.0 equiv.), 12 h. All the yields are isolated yield.



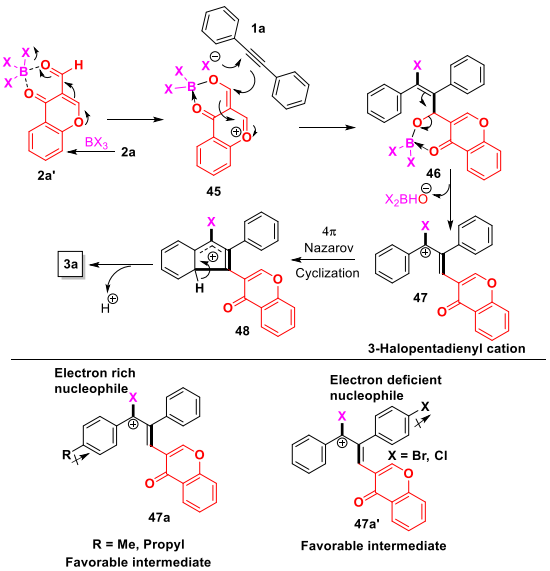
Scheme 5. Various transformation of synthetic compound **3c**.

Additional reactions were also performed with other carbonyl compounds (Scheme 6). Treatment of benzaldehyde (**38**) with **1a** in the presence of $BF_3{\cdot}OEt_2$ did not provide the desired 3-fluoroindene **39**, instead **40** was isolated in 66% yield (Scheme 6a).[17] However, the reactions of **1a** with electron-rich benzaldehydes of *o*- or *p*-anisaldehyde provided intractable mixtures. The reaction of *trans*-cinnamaldehyde (**41**) or 6-oxocyclohex-1-ene-1-carbaldehyde (**42**) with **1a** in the presence of $BF_3{\cdot}OEt_2$ did not provide any desired products. In these cases, the aldehydes were decomposed (Scheme 6b and 6c).The reaction of acetylacetone (**43**) with **1a** in the presence of $BF_3{\cdot}OEt_2$ afforded BF_2-complexed product **44** (83%) (Scheme 6d).[18] These results suggest that using particular structural elements on the substrate aldehydes such as 3-oxocarbaldehydes is crucial for the current protocol.



Scheme 6. Reactions with other carbonyl compounds.

Based on the literature report, a plausible mechanism for the formation of **3a** is proposed in Scheme 7.[15] In the presence of BX_3, 3-formylchromone (**2a**) is converted into complex **2a'**. Tautomerization of **2a'** by oxygen lone pairs forms complex **45** via the release of X^- from BX_3.[19] Intermolecular nucleophilic addition of X^- to **1a** followed by alkyne attack on the carbonyl carbon of **2a'** affords intermediate **46**. Subsequently, **46** converts into 3-halopentadienyl cation **47**. Cyclization of 4π-intermediate **47** to **48** followed by deprotonation affords the observed product **3a**. The regiochemistry of the isolated compounds can be explained by the electronic effects of the substituents. In case of substrates with an electron-releasing group, intermediate **47a** (Scheme 7) would be favourable, affording products **11a-c** and **12a-c**. In contrast, substrates with an electron-withdrawing substituent would generate intermediate **47a'** to provide the cyclized product **13**. In case of acetylene **1h**, the highly electron-donating ethoxy group plays a major role to control the regioselectivity, affording products **14a-b**. The regiochemistry of **14a-b** with **7b-c** and **11b-c** was unambiguously confirmed by ^{1}H NMRs.



Scheme 7. Proposed mechanism for the formation of **3a** and regiochemistry of the synthesized compounds.

Conclusion

In conclusion**,** we have developed a facile and efficient synthetic one-step cascade protocol for the regioselective synthesis of halofunctionalized indenes relying on the dual role of BX_3. The synthesized halofunctionalized indenes can be further derivatized at the C-3 position of the indene moiety through coupling, nucleophilic substitution, and oxidation reactions.

Experimental Section

General remarks: All experiments were carried out in open air. Merck precoated silica gel plates (Art. 5554) with a fluorescent indicator were used for analytical TLC. Flash column chromatography was performed using silica gel 9385 (Merck). The melting points are uncorrected and were determined using micro-cover glasses on a Fisher-Johns apparatus. ^{1}H NMR spectra were recorded on a Varian-VNS (600 MHz) spectrometer using the chemical shift of the solvent at δ = 7.24 ppm for $CDCl_3$ or δ = 0.00 ppm for TMS as a reference. ^{13}C NMR spectra were recorded on a Varian-VNS (150 MHz) spectrometer using the chemical shift of the solvent at δ = 77.0 ppm for $CDCl_3$ as a reference. ^{19}F NMR spectrum was recorded on a Varian-VNS (564 MHz) spectrometer. Chemical shifts (δ) are expressed in units of ppm and *J* values are given in Hz. Multiplicities are abbreviated as follows: s = singlet, d = doublet, t = triplet, q = quartet, brs = broad singlet, dd = doublet of doublets, sept = septet, and m = multiplet. IR spectra were recorded on a FTIR (BIO-RAD) and high-resolution mass spectra were obtained on a JEOL JMS-700 spectrometer at the Korea Basic Science Institute.

General procedure for the Synthesis of 3-33 : To a mixture of alkynes (**1**) (0.5 mmol) and carbaldehydes (**2**) (0.5 mmol) in dichloromethane (1 mL) was added boron reagents (1.0-3.0 equiv.) at room temperature; the mixture was stirred as such. The progress of the reaction was monitored by TLC. After the completion of the reaction, the solvent was removed on a rotary evaporator and the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the crude product, which was purified by short column chromatography over silica gel (EtOAc/hexane = 1:19) to give the desired products.

General Procedure for the Preparation of 34a-b: Compound **3c** (0.5 mmol) was added to a solution of

arylboronic acids (1.5 mmol, 1.5 equiv.), $Pd(OAc)_2$ (5.0 mol %), *S*-Phos (5.0 mol %), and K_3PO_4 (1.0 mmol, 2.0 equiv.) in toluene (2 mL). The solution was then stirred at 80 °C for 12 h. After completion of reaction as indicated by TLC, the solvent was evaporated and the residue was purified over silica gel (EtOAc/hexane = 1:19) to give the desired products **34a-b** in 85-87% yields.

General Procedure for the Preparation of 3-(3-(Furan-2-yl)-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (35): To a solution of bromoindene **3c** (0.5 mmol, 207.0 mg) and 2-(tributylstannyl)furan (0.5 mmol, 178.5 mg) in THF (2 mL) was added $Pd(PPh_3)_2Cl_2$ (5.0 mol %) at room temperature; the mixture was then heated at 60 °C for 12 h. The progress of the reaction was monitored by TLC. After the completion of the reaction, the solvent was removed on a rotary evaporator and the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the crude product, which was purified by short column chromatography over silica gel (EtOAc/hexane = 1:19) to give the desired product **35** in 89% yield (178 mg).

General Procedure for the Preparation of 3-(3-Ethoxy-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (36): To a solution of bromoindene **3c** (0.5 mmol, 207.0 mg) in ethanol (2 mL) was added sodium hydroxide (0.5 mmol, 20.0 mg) at room temperature; the mixture was stirred for 10 min. The progress of the reaction was monitored by TLC. After the completion of the reaction, the solvent was removed on a rotary evaporator and the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the crude product, which was purified by short column chromatography over silica gel (EtOAc/hexane = 1:19) to give the desired product **36** as red colour viscous oils in 55% yield (104 mg).

General Procedure for the Preparation of 3-(1-Oxo-2-phenyl-1*H*-inden-3-yl)-4*H*-chromen-4-one (37): To a solution of bromoindene **3c** (0.5 mmol, 207.0 mg) in DMF (2 mL) was added CuO (0.5 mmol, 40.0 mg) and K_2CO_3 (0.5 mmol, 69.0 mg) at room temperature; the mixture was stirred in open air for 12 h. The progress of the reaction was monitored by TLC. After the completion of the reaction, the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the crude product, which was purified by short column chromatography over silica gel (EtOAc/hexane = 1:19) to give the desired product **37** as orange solid in 67% yield (117 mg).

General Procedure for the Preparation of (2*R*)-2,3-Diphenyl-2,3-dihydro-1*H*-inden-1-one (40): To a mixture of diphenylacetylene (**1a**) (0.5 mmol. 89.0 mg) and benzaldehye (**38**) (0.5 mmol, 53.0 mg) in dichloromethane (1 mL) was added boron trifluoride etherate (0.5 mmol, 1.0 equiv.) and heated the reaction upto 60 °C for 12 h. The progress of the reaction was monitored by TLC. After the completion of the reaction, the solvent was removed on a rotary evaporator and the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the crude product, which was purified by short column chromatography over silica gel (EtOAc/hexane = 1:19) to give the desired product **40** as viscous oils in 66% (187 mg) yield.

General Procedure for the Preparation of 2,2-Difluoro-4,6-dimethyl-2*H*-dioxaborinine (43): To a mixture of diphenylacetylene (**1a**) (0.5 mmol, 89.0 mg) and pentane-2,4-dione (**42**) (0.5 mmol, 50.0 mg) in dichloromethane (1 mL) was added boron trifluoride etherate (0.5 mmol, 1.0 equiv.) at room temperature; the mixture was stirred for 12 h. The progress of the reaction was monitored by TLC. After the completion of the reaction, the solvent was removed on a rotary evaporator and the product was extracted with ethyl acetate (2 × 10 mL) and then washed with brine (5 mL). The organic layer was dried over Na_2SO_4 and evaporated to give the final compound as brown viscous oils **43** in 83% yield (122 mg).

3-(3-Fluoro-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (3a). The title compound (**3a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 185-186 °C. Yield: 65% (115 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.34 (1H, dd, J = 8.1, 1.7 Hz), 7.63-7.60 (1H, m), 7.60-7.58 (2H, m), 7.50 (1H, d, J = 7.8 Hz), 7.44-7.41 (2H, m), 7.37 (1H, s), 7.34-7.30 (4H, m), 7.21-7.18 (2H, m), 5.61 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.7, 157.1 (d, J = 278.1 Hz), 156.3, 152.9, 144.5, 135.3 (d, J = 25.2 Hz), 133.6, 131.3 (d, J = 4.5 Hz), 128.7, 127.7, 127.7, 127.4, 127.2, 125.9, 125.2, 124.0 (d, J = 2.7 Hz), 123.8, 122.6 (d, J = 1.2 Hz), 119.8 (d, J = 2.2 Hz), 118.1, 118.0 (d, J = 2.2 Hz), 40.7; IR (ATR) 3058, 1718, 1622, 1460, 1358, 1145, 1065, 944, 804, 748, 608 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}FO_2$: 354.1056. Found: 354.1056.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (3b). The title compound (**3b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 158-159 °C. Yield: 91% (168 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.18 (1H, d, J = 8.1 Hz), 7.64 (2H, d, J = 7.7 Hz), 7.46-7.41 (2H, m), 7.37 (1H, d, J = 7.5 Hz), 7.27-7.23 (4H, m), 7.18 (1H, s), 7.14-7.09 (3H, m), 5.67 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 156.1, 153.1, 144.8, 141.3, 139.8, 133.5, 132.7, 128.8, 128.5, 128.5, 127.9, 127.5, 126.9, 125.8, 125.1, 123.7, 123.4, 122.5, 119.5, 118.0, 45.2; IR (ATR) 3058, 1625, 1462, 1394, 1352, 1276, 1140, 935, 756, 601 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}ClO_2$: 370.0761. Found: 370.0763.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (3c). The title compound (**3c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 153-154 °C. Yield: 92% (190 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.29 (1H, d, J = 8.1 Hz), 7.75 (2H, d, J = 7.1 Hz), 7.57 (1H, dt, J = 8.4, 1.8 Hz), 7.52 (1H, d, J = 7.6 Hz), 7.46 (1H, d, J = 7.5 Hz), 7.39-7.34 (4H, m), 7.31 (1H, s), 7.27-7.24 (2H, m), 7.21 (1H, t, J = 7.5 Hz), 5.75 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.2, 156.1, 153.1, 145.1, 143.6, 142.6, 133.5, 133.4, 128.6, 128.4, 128.0, 127.5, 126.9, 125.8, 125.1, 123.7, 123.3, 122.4, 120.9, 118.7, 118.0, 46.6; IR (ATR) 3226, 1626, 1459, 1397, 1349, 1275, 1214, 926, 810, 755, 688 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}BrO_2$: 414.0255. Found: 414.0256.

3-(3-Iodo-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (3d). The title compound (**3d**) was prepared according to the general procedure. The product was obtained as a white solid, mp 180-182 °C. Yield: 40% (92 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.25 (1H, d, J = 8.1 Hz), 7.68 (2H, d, J = 7.0 Hz), 7.60-7.57 (1H, m), 7.44 (1H, d, J = 7.5 Hz), 7.39-7.34 (5H, m), 7.32-7.31 (1H, m), 7.28-7.26 (2H, m), 7.19 (1H, dt, J = 7.8, 1.2 Hz), 5.72 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.1, 156.1, 153.1, 150.7, 145.0, 135.0, 133.6, 131.5, 128.8, 128.4, 128.2, 127.6, 126.9, 125.9, 125.2, 123.8, 123.3, 123.2, 122.4, 118.1, 94.9, 48.1; IR (ATR) 2877, 1596, 1513, 1441, 1416, 1368, 1321, 1261, 1143, 1025, 927, 819, 756, 582 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}IO_2$: 462.0117. Found: 462.0120.

3-(3-Fluoro-2-phenyl-1*H*-inden-1-yl)-6-methyl-4*H*-chromen-4-one (4a). The title compound (**4a**) was prepared according to the general procedure. The product was obtained as a white solid and recrystallized with hexane/ethylacetate, mp 162-163 °C. Yield: 66% (121 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.13 (1H, s), 7.59 (2H, d, J = 8.1 Hz), 7.50 (1H, d, J = 7.5 Hz), 7.44-7.40 (2H, m), 7.32 (4H, t, J = 7.9 Hz), 7.20-7.18 (3H, m), 5.61 (1H, brs),

2.46 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.7, 157.1 (d, J = 278.2 Hz), 154.5, 152.8, 144.6, 135.3 (d, J = 25.0 Hz), 135.2, 134.8, 131.3 (d, J = 4.6 Hz), 128.7, 127.7 (d, J = 5.7 Hz), 127.3, 127.2, 127.1, 125.1, 124.0 (d, J = 2.7 Hz), 123.5, 122.3 (d, J = 1.8 Hz), 119.8 (d, J = 2.2 Hz), 117.9 (d, J = 2.2 Hz), 117.8, 40.7, 20.9; ^{19}F NMR: (564 MHz, $CDCl_3$) δ -129.9 (1F, s); IR (ATR) 3068, 1719, 1612, 1462, 1359, 1155, 1061, 945, 801, 745, 609 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}FO_2$: 368.1213. Found: 368.1211.

X-Ray crystallographic data of compound 4a: Empirical Formula- $C_{25}H_{17}FO_2$, M = 368.38, Triclinic, Space group P-1, a = 8.3916(10) Å, b = 9.3062(11) Å, c = 13.6203(13) Å, V = 920.86(18) Å^3, Z = 2, T = 223(2) K, ρ_{calcd} = 1.329 Mg/m^3, $2\Theta_{max.}$ = 28.487°, Refinement of 254 parameters on 4639 independent reflections out of 30629 collected reflections (R_{int} = 0.0769) led to R_1 = 0.0561 [I >2σ(I)], wR_2 = 0.1063 (all data) and S = 1.044 with the largest difference peak and hole of 0.267 and -0.207 e.Å^{-3} respectively. The crystal structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC 1909137). The data can be obtained free of charge via the Internet at www.ccdc.cam.ac.uk/data_request/cif.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-6-methyl-4*H*-chromen-4-one (4b). The title compound (**4b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 166-167 °C. Yield: 90% (172 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.10 (1H, s), 7.77 (2H, d, J = 7.8 Hz), 7.53 (1H, d, J = 7.2 Hz), 7.49 (1H, d, J = 7.2 Hz), 7.38-7.34 (4H, m), 7.25-7.20 (3H, m), 7.13 (1H, d, J = 9.0 Hz), 5.80 (1H, brs), 2.43 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 154.3, 152.9, 144.9, 141.3, 139.8, 135.0, 134.7, 132.6, 128.7, 128.5, 128.4, 127.8, 127.4, 126.8, 125.0, 123.4, 123.3, 122.2, 119.4, 117.7, 45.2, 20.8; IR (ATR) 3057, 1626, 1461, 1392, 1352, 1277, 1140, 935, 756, 605 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}ClO_2$: 384.0917. Found: 384.0913.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-6-methyl-4*H*-chromen-4-one (4c). The title compound (**4c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 175-176 °C. Yield: 92% (196 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.92 (1H, s), 7.62 (2H, d, J = 8.2 Hz), 7.36 (1H, d, J = 7.4 Hz), 7.32 (1H, d, J = 7.5 Hz), 7.22-7.19 (4H, m), 7.11-7.05 (3H, m), 6.97 (1H, d, J = 8.5 Hz), 5.62 (1H, brs), 2.27 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.1, 154.2, 152.9, 145.0, 143.5, 142.4, 135.0, 134.7, 133.3, 128.5, 128.3, 127.9, 127.4, 126.8, 124.9, 123.2, 123.2, 121.9, 120.7, 118.5, 117.6, 46.4, 20.8; IR (ATR) 3216, 1626, 1452, 1397, 1341, 1272, 1224, 926, 811, 756, 685 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}BrO_2$: 428.0412. Found: 428.0414.

3-(3-Fluoro-2-phenyl-1*H*-inden-1-yl)-6-nitro-4*H*-chromen-4-one (5a). The title compound (**5a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 190-191 °C. Yield: 62% (123 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.21 (1H, d, J = 2.8 Hz), 8.44 (1H, dd, J = 9.1, 2.8 Hz), 7.56 (2H, d, J = 7.2 Hz), 7.48-7.42 (4H, m), 7.36-7.33 (3H, m), 7.21 (2H, t, J = 7.5 Hz), 5.56 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.4, 159.0, 157.2 (d, J = 278.1 Hz), 153.2, 144.8, 143.7, 135.3 (d, J = 25.5 Hz), 131.0 (d, J = 4.9 Hz), 128.9, 127.9, 127.7, 127.6, 127.6, 127.4, 127.4, 123.9 (d, J = 2.5 Hz), 123.8, 122.8, 119.9, 119.3 (d, J = 3.1 Hz), 118.2 (d, J = 2.2 Hz), 40.6; IR (ATR) 3293, 1650, 1525, 1449, 1379, 1318, 1262, 1212, 1138, 1070, 991, 756, 686, 591 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}FNO_4$: 399.0907. Found: 399.0909.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-6-nitro-4*H*-chromen-4-one (5b). The title compound (**5b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 175-176 °C. Yield: 73% (151 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.16 (1H, d, J = 2.8 Hz), 8.42 (1H, dd, J = 9.1, 2.8 Hz), 7.72 (2H, d, J = 7.6 Hz), 7.53 (1H, d, J = 7.5 Hz), 7.45 (2H, d, J = 9.0 Hz), 7.40-7.36 (4H, m), 7.27 (1H, t, J = 7.4 Hz), 7.24-7.22 (1H, m), 5.72 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.1, 158.9, 153.4, 144.7, 144.1, 141.4, 139.2, 132.4, 129.4, 128.7, 128.5, 128.2, 127.9, 127.9, 127.2, 123.8, 123.7, 123.4, 122.8, 119.9, 119.8, 45.1; IR (ATR) 3295, 1651, 1525, 1449, 1378, 1328, 1261, 1222, 1137, 1072, 991, 757, 688, 591 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}ClNO_4$: 415.0611. Found: 415.0610.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-6-nitro-4*H*-chromen-4-one (5c). The title compound (**5c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 184-185 °C. Yield: 77% (176 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.12 (1H, d, J = 2.8 Hz), 8.40 (1H, dd, J = 9.2, 2.8 Hz), 7.72 (2H, d, J = 7.5 Hz), 7.50 (1H, d, J = 7.6 Hz), 7.44-7.41 (2H, m), 7.39-7.35 (4H, m), 7.27 (1H, t, J = 7.4 Hz), 7.21 (1H, td, J = 7.5, 1.1 Hz), 5.67 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 175.9, 158.8, 153.4, 144.6, 144.2, 142.9, 142.6, 133.1, 128.6, 128.2, 128.2, 127.8, 127.8, 127.1, 123.6, 123.5, 123.2, 122.7, 121.0, 119.8, 119.3, 46.4; IR (ATR) 3290, 1653, 1515, 1439, 1389, 1314, 1263, 1210, 1138, 1070, 992, 757, 687, 591 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}BrNO_4$: 459.0106. Found: 459.0104.

6-Chloro-3-(3-fluoro-2-phenyl-1*H*-inden-1-yl)-8-methyl-4*H*-chromen-4-one (6a). The title compound (**6a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 226-227 °C. Yield: 60% (120 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.27 (1H, s), 7.56 (2H, d, J = 8.3 Hz), 7.47 (1H, d, J = 7.6 Hz), 7.43 (1H, d, J = 7.5 Hz), 7.33-7.29 (4H, m), 7.21-7.17 (3H, m), 5.56 (1H, brs), 2.43 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.6, 157.1 (d, J = 278.1 Hz), 154.5, 152.8, 144.34, 143.0, 135.3 (d, J = 25.2 Hz), 131.9, 131.2 (d, J = 4.5 Hz), 128.7, 127.7, 127.6, 127.5, 127.2, 125.5, 124.0 (d, J = 2.2 Hz), 122.9, 122.6, 119.8, 119.7 (d, J = 1.9 Hz), 118.0 (d, J = 2.2 Hz), 40.7, 20.7; IR (ATR) 3054, 1716, 1625, 1450, 1357, 1146, 1063, 945, 804, 749, 609 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{16}ClFO_2$: 402.0823. Found: 402.0822.

6-Chloro-3-(3-chloro-2-phenyl-1*H*-inden-1-yl)-8-methyl-4*H*-chromen-4-one (6b). The title compound (**6b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 185-186 °C. Yield: 77% (160 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.23 (1H, s), 7.74 (2H, d, J = 7.2 Hz), 7.53 (1H, d, J = 7.2 Hz), 7.46 (1H, d, J = 7.5 Hz), 7.39-7.35 (3H, m), 7.26-7.21 (3H, m), 7.12 (1H, s), 5.74 (1H, brs), 2.40 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.2, 154.4, 153.0, 144.7, 142.9, 141.3, 139.7, 132.6, 131.8, 128.9, 128.5, 128.5, 127.9, 127.5, 127.0, 125.4, 123.4, 122.7, 122.5, 119.7, 119.6, 45.1, 20.6; IR (ATR) 3258, 1627, 1452, 1384, 1351, 1276, 1141, 965, 756, 611 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{16}Cl_2O_2$: 418.0527. Found: 418.0526.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-6-chloro-7-methyl-4*H*-chromen-4-one (6c). The title compound (**6c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 181-182 °C. Yield: 79% (182 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.09 (1H, s), 7.62 (2H, d, J = 7.8 Hz), 7.40 (1H, d, J = 7.6 Hz) 7.31 (1H, d, J = 7.5 Hz), 7.27-7.22 (3H, m), 7.14 (1H, t, J = 7.7 Hz), 7.09 (2H, t, J = 7.2 Hz), 6.98 (1H, s), 5.59 (1H, brs), 2.27 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.0, 154.3, 153.0, 144.9, 143.4, 142.8, 142.5, 133.3, 131.8, 128.6, 128.4, 128.0, 127.6, 126.9, 125.4, 123.2, 122.7, 122.2, 120.9, 119.7, 118.8, 46.4, 20.6; IR (ATR) 3064, 1628, 1564, 1458, 1393, 1339, 1265, 1214, 1071, 1064, 929, 836, 756, 587 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{16}BrClO_2$: 462.0022. Found: 462.0025.

3-(3-Fluoro-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (7a). The title compound (**7a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 195-196 °C. Yield: 59% (112 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.35 (1H, d, J =

7.4 Hz), 7.62 (1H, dt, *J* = 7.8, 1.2 Hz), 7.46-7.41 (3H, m), 7.36 (1H, s), 7.32-7.29 (3H, m), 7.12 (3H, d, *J* = 7.9 Hz), 5.53 (1H, brs), 2.31 (3H, s), 2.29 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.8, 156.8 (d, *J* = 277.0 Hz), 156.3, 153.0, 137.2, 136.9, 133.6, 129.4, 128.7, 128.1, 127.5 (d, *J* = 6.3 Hz), 125.9, 125.5, 125.1, 124.8 (d, *J* = 3.4 Hz), 124.1, 123.9, 122.9, 118.7, 118.1, 117.5 (d, *J* = 2.4 Hz), 40.4, 21.6, 21.2; IR (ATR) 3158, 1712, 1623, 1460, 1354, 1155, 1045, 935, 804, 748, 618 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{19}FO_2$: 382.1369. Found: 382.1372.

3-(3-Chloro-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (7b). The title compound (**7b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 191-192 °C. Yield: 88% (175 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.31 (1H, d, *J* = 8.4 Hz), 7.62 (2H, d, *J* = 8.4 Hz), 7.60-7.58 (1H, m), 7.41-7.38 (2H, m), 7.30-7.27 (3H, m), 7.17-7.14 (3H, m), 5.72 (1H, brs), 2.32 (3H, s), 2.29 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.5, 156.2, 153.2, 145.1, 138.9, 138.7, 137.7, 136.9, 133.5, 130.0, 129.2, 128.3, 128.2, 128.2, 125.9, 125.1, 124.2, 123.8, 122.9, 119.1, 118.1, 44.9, 21.5, 21.2; IR (ATR) 3158, 1625, 1464, 1353, 1354, 1276, 1151, 937, 757, 601 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{19}ClO_2$: 398.1074. Found: 398.1073.

3-(3-Bromo-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (7c). The title compound (**7c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 240-242 °C. Yield: 89% (196 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.30 (1H, d, *J* = 7.8 Hz), 7.64 (2H, d, *J* = 8.4 Hz), 7.59-7.57 (1H, m), 7.40-7.37 (2H, m), 7.30 (1H, s), 7.28-7.26 (2H, m), 7.18-7.15 (3H, m), 5.70 (1H, brs), 2.33 (3H, s), 2.29 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.4, 156.2, 153.2, 145.2, 142.4, 140.1, 137.8, 136.9, 133.5, 130.6, 129.2, 128.5, 128.2, 125.9, 125.1, 124.1, 123.8, 122.7, 120.4, 118.0, 118.0, 46.2, 21.4, 21.2; IR (ATR) 3164, 1628, 1564, 1458, 1390, 1349, 1265, 1214, 1072, 1004, 925, 818, 756, 599 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{19}BrO_2$: 442.0567. Found: 442.0568.

3-(3-Iodo-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-6-isopropyl-4*H*-chromen-4-one (8). The title compound (**8**) was prepared according to the general procedure. The product was obtained as a white solid, mp 178-179 °C. Yield: 53% (140 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.12 (1H, s), 7.58 (2H, d, *J* = 7.8 Hz), 7.46 (1H, d, *J* = 9.0 Hz), 7.31-7.26 (2H, m), 7.22-7.21 (2H, m), 7.17-7.14 (3H, m), 5.70 (1H, brs), 3.01 (1H, sept, *J* = 7.2 Hz), 2.33 (3H, s), 2.29 (3H, s), 1.29 (6H, d, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.4, 154.6, 153.1, 149.5, 146.0, 145.7, 142.6, 137.9, 136.8, 132.5, 132.1, 129.1, 128.6, 128.2, 123.9, 123.5, 122.7, 122.5, 122.4, 117.9, 93.9, 47.8, 33.7, 23.9, 23.8, 21.3, 21.2; IR (ATR) 2871, 1588, 1512, 1451, 1419, 1356, 1310, 1261, 1143, 1012, 927, 816, 757, 588 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{29}H_{25}IO_2$: 532.0899. Found: 532.0901.

3-(5-Bromo-2-(3-bromophenyl)-3-chloro-1*H*-inden-1-yl)-4*H*-chromen-4-one (9). The title compound (**9**) was prepared according to the general procedure. The product was obtained as a white solid, mp 240-242 °C. Yield: 54% (141 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.26 (1H, d, *J* = 7.8 Hz), 7.95 (1H, s), 7.65 (1H, s), 7.61 (1H, dt, *J* = 6.6, 1.2 Hz), 7.53 (1H, d, *J* = 7.2 Hz), 7.41-7.37 (2H, m), 7.34-7.27 (4H, m), 7.210 (1H, t, *J* = 8.4 Hz), 5.63 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.1, 153.1, 143.0, 140.0, 134.3, 133.8, 131.3, 131.2, 130.2, 130.1, 129.5, 128.9, 127.2, 125.9, 125.4, 125.0, 123.6, 123.0, 122.7, 121.7, 121.6, 118.1, 45.2; IR (ATR) 3062, 1627, 1565, 1458, 13921, 1339, 1265, 1224, 1071, 1014, 966, 813, 755, 590 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{13}Br_2ClO_2$: 525.8971. Found: 525.8969.

3-(6-Bromo-2-(4-bromophenyl)-3-chloro-1*H*-inden-1-yl)-4*H*-chromen-4-one (10a). The title compound (**10a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 194-195 °C. Yield: 63% (165 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.28 (1H, d, *J* = 7.8 Hz), 7.65-7.62 (1H, m), 7.59-7.57 (3H, m), 7.50 (1H, dd, *J* = 8.4, 1.8 Hz), 7.48-7.45 (2H, m), 7.42 (1H, t, *J* = 7.8 Hz), 7.37 (1H, d, *J* = 7.8 Hz), 7.32 (1H, d, *J* = 8.4 Hz), 7.29 (1H, s), 5.68 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.1, 156.2, 153.3, 146.4, 140.3, 139.2, 133.9, 131.9, 131.2, 130.9, 130.0, 128.8, 126.8, 126.0, 125.4, 123.7, 122.4, 121.7, 121.4, 121.0, 118.1, 45.1; IR (ATR) 3064, 1625, 1561, 1452, 1392, 1341, 1285, 1211, 1081, 1014, 927, 814, 753, 589 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{13}Br_2ClO_2$: 525.8971. Found: 525.8974.

3-(3,6-Dibromo-2-(4-bromophenyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (10b). The title compound (**10b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 188-190 °C. Yield: 67% (190 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.26 (1H, d, *J* = 7.2 Hz), 7.62 (1H, dt, *J* = 6.6, 1.8 Hz), 7.58 (2H, d, *J* = 8.4 Hz), 7.55 (1H, s), 7.50 (1H, d, *J* = 8.4 Hz), 7.47-7.45 (2H, m), 7.41 (1H, t, *J* = 7.8 Hz), 7.35 (1H, d, *J* = 7.8 Hz), 7.32 (1H, d, *J* = 8.4 Hz), 7.29 (1H, s), 5.65 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.2, 153.3, 146.6, 143.0, 141.5, 133.9, 132.0, 131.8, 130.9, 130.1, 126.6, 126.0, 125.4, 123.6, 122.6, 122.3, 121.5, 121.4, 118.4, 118.1, 46.6; IR (ATR) 3064, 1624, 1568, 1458, 1392, 1349, 1275, 1214, 1071, 1004, 926, 816, 753, 589 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{13}Br_3O_2$: 569.8466. Found: 569.8470.

3-(3-Fluoro-2-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (11a). The title compound (**11a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 243-244 °C. Yield: 64% (117 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.35 (1H, d, *J* = 7.8 Hz), 7.62 (1H, dt, *J* = 8.4, 1.2 Hz), 7.56 (2H, d, *J* = 7.8 Hz), 7.43 (1H, d, *J* = 7.2 Hz), 7.37 (1H, s), 7.32-7.30 (5H, m), 7.18 (1H, t, *J* = 7.2 Hz), 7.12 (1H, d, *J* = 7.2 Hz), 5.56 (1H, brs), 2.31 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.8, 157.3 (d, *J* = 278.1 Hz), 156.3, 153.0, 144.8, 137.4, 133.6, 131.5 (d, *J* = 4.3 Hz), 129.4, 128.7, 128.1, 127.5 (d, *J* = 6.9 Hz), 126.9, 125.9, 125.2, 124.8, 123.9, 122.8, 118.7, 118.1, 117.7 (d, *J* = 2.2 Hz), 40.4, 21.6; IR (ATR) 3053, 1719, 1612, 1455, 1358, 1135, 1035, 944, 805, 748, 618 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}FO_2$: 368.1213. Found: 368.1216.

5-(3-Chloro-2-(*p*-tolyl)-1*H*-inden-1-yl)-2,3-dihydro-4*H*-pyran-4-one (11b). The title compound (**11b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 179- 180 °C. Yield: 89% (170 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.19 (1H, d, *J* = 7.8 Hz), 7.62 (2H, d, *J* = 7.2 Hz), 7.42 (1H, dt, *J* = 7.8, 1.2 Hz), 7.29 (1H, dd, *J* = 7.8, 3.0 Hz), 7.26-7.17 (5H, m), 7.12-7.08 (2H, m), 7.05 (1H, d, *J* = 7.8 Hz), 5.63 (1H, brs), 2.20 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.2, 156.0, 153.1, 145.2, 142.4, 140.0, 137.0, 133.4, 129.1, 128.5, 128.4, 128.2, 127.8, 125.8, 125.0, 124.0, 123.7, 122.5, 120.5, 118.7, 118.0, 46.3, 21.3; IR (ATR) 3051, 1625, 1463, 1395, 1351, 1275, 1144, 955, 756, 611 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}ClO_2$: 384.0917. Found: 384.0920.

3-(3-Bromo-2-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (11c). The title compound (**11c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 180-182 °C. Yield: 88% (188 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.18 (1H, d, *J* = 7.8 Hz), 7.63 (2H, d, *J* = 7.8 Hz), 7.43 (1H, t, *J* = 6.6 Hz), 7.28-7.21 (4H, m), 7.18-7.17 (2H, m), 7.12 (2H, d, *J* = 7.8 Hz), 7.06 (1H, d, *J* = 7.8 Hz), 5.61 (1H, brs), 2.21 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.2, 156.0, 153.1, 145.2, 142.4, 140.0, 137.0, 133.5, 133.4, 128.5, 128.4, 128.2, 127.8, 125.8, 125.0, 124.0, 123.7, 122.5, 120.5, 118.7, 118.0, 46.3, 21.4; IR (ATR) 3024, 1624, 1563, 1468, 1321, 13411, 1275, 1214, 1071, 1034, 927, 811, 756, 585 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{17}BrO_2$: 428.0412. Found: 428.0409.

3-(3-Fluoro-2-(4-propylphenyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (12a). The title compound (**12a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 125-126 ºC. Yield: 62% (122 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.35 (1H, d, *J* = 7.8 Hz), 7.62 (1H, dt, *J* = 8.4, 1.8 Hz), 7.56 (2H, d, *J* = 7.8 Hz), 7.43 (1H, t, *J* = 7.8 Hz), 7.37 (1H, s), 7.34-7.29 (5H, m), 7.17 (1H, t, *J* = 7.2 Hz), 7.13 (1H, d, *J* = 7.8 Hz), 5.57 (1H, brs), 2.54 (2H, t, *J* = 8.4 Hz), 1.61-1.53 (2H, m), 0.88 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.8, 157.3 (d, *J* = 278.1 Hz), 156.3, 153.0, 144.9, 142.5, 133.6, 133.0 (d, *J* = 24.5 Hz), 131.6, 128.7, 127.6, 127.6 (d, *J* = 5.7 Hz), 126.9, 126.0, 125.2, 124.2, 123.9, 122.8, 118.9, 118.1, 117.7 (d, *J* = 1.9 Hz), 40.5, 38.2, 24.8, 13.8; IR (ATR) 3048, 1719, 1621, 1470, 1368, 1141, 1035, 955, 814, 748, 608 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{21}FO_2$: 396.1526. Found: 396.1528.

3-(3-Chloro-2-(4-propylphenyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (12b). The title compound (**12b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 145-146 ºC. Yield: 87% (179 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.19 (1H, d, *J* = 7.8 Hz), 7.62 (2H, d, *J* = 7.8 Hz), 7.42 (1H, dt, *J* = 8.4, 1.8 Hz), 7.31 (1H, d, *J* = 7.8 Hz), 7.26-7.19 (4H, m), 7.16 (1H, s), 7.11-7.06 (3H, m), 5.65 (1H, brs), 2.43 (2H, t, *J* = 7.8 Hz), 1.51-1.42 (2H, m), 0.77 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 156.1, 153.2, 145.1, 142.1, 139.1, 138.9, 133.4, 132.8, 128.9, 128.4, 128.4, 127.7, 127.7, 125.8, 125.0, 123.7, 123.6, 122.7, 119.2, 118.0, 44.9, 38.0, 24.7, 13.7; IR (ATR) 3158, 1626, 1462, 1354, 1353, 1276, 1150, 936, 755, 601 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{21}ClO_2$: 412.1230. Found: 412.1230.

3-(3-Bromo-2-(4-propylphenyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (12c). The title compound (**12c**) was prepared according to the general procedure. The product was obtained as a white solid and recrystallized with hexane/ethylacetate, mp 149-150 ºC. Yield: 86% (196 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.29 (1H, d, *J* = 8.4 Hz), 7.72 (2H, d, *J* = 7.8 Hz), 7.59 (1H, dt, *J* = 7.2, 1.8 Hz), 7.41-7.38 (2H, m), 7.35-7.31 (3H, m), 7.29 (1H, d, *J* = 8.4 Hz), 7.25-7.22 (2H, m), 7.18 (1H, d, *J* = 7.8 Hz), 5.72 (1H, brs), 2.55 (2H, t, *J* = 7.2 Hz), 1.62-1.55 (2H, m), 0.88 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.4, 156.2, 153.3, 145.4, 142.7, 142.2, 140.4, 133.6, 133.5, 128.6, 128.4, 127.9, 127.8, 125.9, 125.1, 123.8, 123.6, 122.6, 120.6, 118.8, 118.1, 46.3, 38.1, 24.8, 13.8; IR (ATR) 3014, 1626, 1561, 1468, 1382, 1359, 1275, 1213, 1070, 1004, 925, 814, 756, 569 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{21}BrO_2$: 456.0725. Found: 456.0726.

X-Ray crystallographic data of compound 12c: Empirical Formula- $C_{27}H_{21}BrO_2$, M = 457.35, Triclinic, Space group P-1, a = 9.5557(9) Å, b = 10.1329(8) Å, c = 11.2305(10) Å, V = 1056.67(16) Å^3, Z = 2, T = 223(2) K, ρ_{calcd} = 1.437 Mg/m^3, $2\Theta_{max.}$ = 28.382º, Refinement of 272 parameters on 5292 independent reflections out of 34874 collected reflections (R_{int} = 0.0317) led to R_1 = 0.0364 [I >2σ(I)], wR_2 = 0.0960 (all data) and S = 1.039 with the largest difference peak and hole of 1.133 and -0.583 e.Å^{-3} respectively. The crystal structure has been deposited at the Cambridge Crystallographic Data Centre (CCDC 1909140). The data can be obtained free of charge via the Internet at www.ccdc.cam.ac.uk/data_request/cif.

3-(2-(4-Chlorophenyl)-3-fluoro-1*H*-inden-1-yl)-4*H*-chromen-4-one (13). The title compound (**13**) was prepared according to the general procedure. The product was obtained as a white solid, mp 142-143 ºC. Yield: 48% (93 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.33 (1H, d, *J* =7.8 Hz), 7.63 (1H, dt, *J* = 7.2, 1.2 Hz), 7.51 (2H, d, *J* = 8.4 Hz), 7.47 (1H, d, *J* =7.2 Hz), 7.44-7.42 (2H, m), 7.34-7.31 (3H, m), 7.28 (2H, d, *J* = 9.0 Hz) 7.21 (1H, t, *J* =7.2 Hz), 5.56 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.6, 157.3 (d, *J* = 278.2 Hz), 156.2, 153.0, 144.4, 135.1 (d, *J* = 24.1 Hz), 133.8, 132.9, 129.8, 129.0, 128.9, 128.8, 127.5, 127.5, 125.9, 125.3, 124.0, 123.7, 122.3, 118.9, 118.1 (d, *J* = 2.1 Hz), 40.6; IR (ATR) 3054, 1717, 1627, 1450, 1358, 1245, 1045, 933, 832, 748, 618 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}ClFO_2$: 388.0666. Found: 388.0663.

3-(3-Chloro-2-(4-ethoxyphenyl)-6-methyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (14a). The title compound (**14a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 179-180 ºC. Yield: 79% (169 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.30 (1H, d, *J* = 7.8 Hz), 7.61 (2H, d, *J* = 7.2 Hz), 7.58 (1H, t, *J* = 8.4 Hz), 7.40-7.37 (2H, m), 7.31 (1H, s), 7.28 (1H, d, *J* = 8.4 Hz), 7.14 (2H, d, *J* = 8.4 Hz), 7.06 (1H, s), 6.89 (1H, dd, *J* = 8.4, 1.8 Hz), 5.71 (1H, brs), 4.01-3.94 (2H, m), 2.29 (3H, s), 1.34 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.4, 158.8, 156.2, 153.3, 146.7, 137.7, 137.5, 134.3, 133.5, 130.1, 129.2, 128.2, 127.9, 125.9, 125.1, 123.8, 123.0, 120.1, 118.0, 113.8, 110.3, 63.8, 45.0, 21.2, 14.7; IR (ATR) 3021, 1629, 1568, 1462, 1321, 1340, 1275, 1213, 1061, 1033, 924, 812, 757, 587 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{21}ClO_3$: 428.1179. Found: 428.1181.

3-(3-Bromo-2-(4-ethoxyphenyl)-6-methyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (14b). The title compound (**14b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 164-165 ºC. Yield: 73% (172 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.28 (1H, d, *J* = 7.8 Hz), 7.62-7.57 (3H, m), 7.40-7.34 (2H, m), 7.31 (1H, s), 7.28 (1H, d, *J* = 8.4 Hz), 7.14 (2H, d, *J* = 8.4 Hz), 7.03 (1H, s), 6.88 (1H, dd, *J* = 9.2, 2.4 Hz), 5.67 (1H, brs), 4.01-3.94 (2H, m), 2.28 (3H, s), 1.34 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 158.8, 156.2, 153.3, 146.8, 141.2, 137.6, 137.6, 133.5, 130.7, 129.2, 128.3, 125.9, 125.1, 123.8, 122.8, 121.4, 118.0, 117.6, 113.8, 110.1, 63.8, 46.4, 21.3, 14.7; IR (ATR) 3021, 1629, 1568, 1462, 1321, 1340, 1275, 1213, 1061, 1033, 924, 812, 757, 587 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{21}BrO_3$: 472.0674. Found: 472.0675.

3-(3-Chloro-2-methyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (15a). The title compound (**15a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 146-147 ºC. Yield: 73% (112 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.29 (1H, d, *J* = 8.4 Hz), 7.65 (1H, dt, *J* = 7.2, 1.8 Hz), 7.43-7.37 (3H, m), 7.33-7.30 (3H, m), 7.16 (1H, t, *J* = 7.2 Hz), 5.01 (1H, brs), 2.02 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 156.3, 152.8, 144.3, 141.8, 140.2, 133.6, 128.3, 127.3, 125.9, 125.8, 125.2, 123.7, 123.2, 122.3, 118.6, 118.1, 46.9, 12.4; IR (ATR) 1728, 1627, 1461, 1392, 1344, 1216, 1140, 1036, 944, 848, 755 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{13}ClO_2$: 308.0604. Found: 308.0601.

3-(3-Iodo-2-methyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (15b). The title compound (**15b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 146-147 ºC. Yield: 57% (113 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.19 (1H, d, *J* = 7.8 Hz), 7.55-7.52 (1H, m), 7.31 (1H, t, *J* = 7.8 Hz), 7.28 (1H, d, *J* = 8.4 Hz), 7.23-7.19 (2H, m), 7.15 (2H, t, *J* = 7.8 Hz), 7.03 (1H, t, *J* = 7.2 Hz), 4.96 (1H, brs), 1.97 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.2, 152.8, 150.6, 145.1, 144.9, 133.6, 127.4, 125.9, 125.9, 125.2, 123.7, 122.9, 122.2, 121.8, 118.0, 94.9, 48.7, 17.3; IR (ATR) 1729, 1628, 1467, 1395, 1314, 1236, 1142, 1037, 945, 847, 757 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{19}H_{13}IO_2$: 399.9960. Found: 399.9961.

3-(2-Butyl-3-Chloro-1*H*-inden-1-yl)-4*H*-chromen-4-one (16a). The title compound (**16a**) was prepared according to the general procedure. The product was obtained as a colorless liquid. Yield: 85% (167 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.31 (1H, d, *J* = 7.2 Hz), 7.62 (1H, dt, *J* = 9.0, 1.8 Hz), 7.42-7.34 (4H, m), 7.32-7.29 (2H, m), 7.15 (1H, t, *J* = 7.2 Hz), 5.17 (1H, brs), 2.74-2.69 (1H, m), 2.20-2.13 (1H, m), 1.60-1.53 (1H, m), 1.51-1.45 (1H, m), 1.39-1.26 (2H, m), 0.88 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.1, 152.7, 144.7, 144.3, 141.5, 133.5, 128.3, 128.0, 127.1, 125.8, 125.1, 123.6, 123.1, 122.1, 118.6, 117.9, 44.7, 30.7, 26.2, 22.3, 13.6; IR (ATR) 2929, 2862, 1725, 1641, 1462, 1335, 1275, 1217, 1143, 1110,

988, 861, 758, 603 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}ClO_2$: 350.1074 Found: 350.1073.

3-(3-Bromo-2-butyl-1H-inden-1-yl)-4H-chromen-4-one (16b). The title compound (**16b**) was prepared according to the general procedure. The product was obtained as a colorless liquid. Yield: 86% (169 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 8.31 (1H, d, *J* = 6.6 Hz), 7.64 (1H, dt, *J* = 7.2, 1.2 Hz), 7.42 (1H, t, *J* = 7.8 Hz), 7.39-7.36 (2H, m), 7.33-7.30 (3H, m), 7.14 (1H, t, *J* = 7.8 Hz), 5.16 (1H, brs), 2.71-2.66 (1H, m), 2.20-2.16 (1H, m), 1.60-1.52 (1H, m), 1.51-1.45 (1H, m), 1.38-1.28 (2H, m), 0.88 (3H, t, *J* = 7.8 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.2, 152.8, 147.9, 145.0, 142.6, 133.6, 128.0, 127.2, 125.9, 125.2, 123.7, 123.1, 122.1, 119.8, 118.6, 118.0, 45.7, 30.7, 27.8, 22.4, 13.7; IR (ATR) 2928, 2862, 1723, 1643, 1461, 1337, 1276, 1218, 1142, 1111, 987, 863, 756, 605 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}BrO_2$: 394.0568. Found: 394.0569.

3-(2-Butyl-3-iodo-1*H*-inden-1-yl)-4*H*-chromen-4-one (16c). The title compound (**16c**) was prepared according to the general procedure. The product was obtained as a colorless liquid. Yield: 67% (167 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 8.22 (1H, s), 7.57 (1H, dt, *J* = 7.2, 1.8 Hz), 7.35 (1H, t, *J* = 7.8 Hz), 7.31 (1H, d, *J* = 9.0 Hz), 7.26-7.23 (1H, m), 7.21-7.16 (3H, m), 7.05 (1H, dt, *J* = 7.2, 1.2 Hz), 5.13 (1H, brs), 2.57-2.52 (1H, m), 2.19-2.15 (1H, m), 1.52-1.45 (1H, m), 1.42-1.36 (1H, m), 1.30-1.21 (2H, m), 0.80 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 156.2, 154.7, 152.9, 145.5, 144.9, 133.6, 127.4, 126.1, 126.0, 125.2, 123.8, 123.0, 122.3, 122.0, 118.1, 95.1, 46.6, 31.0, 30.9, 22.5, 13.8; IR (ATR) 2928, 2852, 1727, 1642, 1432, 1345, 1276, 1218, 1142, 1112, 987, 862, 757, 605 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}IO_2$: 442.0430 Found: 442.0432.

3-(3-Chloro-2-(thiophen-3-yl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (17). The title compound (**17**) was prepared according to the general procedure. The product was obtained as a white solid, mp 157-158 °C. Yield: 72% (135 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 8.30 (1H, dd, *J* = 7.8, 1.8 Hz), 7.66 (2H, dd, *J* = 7.2, 1.2 Hz), 7.59 (1H, dt, *J* = 7.2, 1.2 Hz), 7.40-7.34 (4H, m), 7.29-7.23 (3H, m), 7.03 (1H, d, *J* = 4.8 Hz), 5.52 (1H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 156.2, 152.7, 146.9, 144.6, 140.1, 133.7, 133.3, 128.8, 128.7, 127.8, 127.5, 126.2, 125.8, 125.2, 123.5, 122.2, 118.0, 117.7, 44.5; IR (ATR) 1624, 1460, 1385, 1353, 1205, 1134, 899, 761, 682 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{13}ClO_2S$: 376.0325. Found: 376.0326.

3-(3-Chloro-2-(naphthalen-1-yl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (18). The title compound (**18**) was prepared according to the general procedure. The product was obtained as a white solid, mp 190-192 °C. Yield: 92% (193 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 9.31 (1H, d, *J* = 9.0 Hz), 8.29 (1H, d, *J* = 8.4 Hz), 7.83 (1H, d, *J* = 8.4 Hz), 7.73 (2H, d, *J* = 7.2 Hz), 7.68 (1H, d, *J* = 8.4 Hz), 7.56-7.52 (3H, m), 7.46 (1H, dt, *J* = 7.2, 1.2 Hz), 7.37-7.34 (3H, m), 7.27-7.21 (3H, m), 5.81 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.2, 156.1, 153.3, 144.6, 142.3, 134.2, 133.7, 133.5, 133.0, 129.4, 128.9, 128.8, 128.4, 128.1, 127.9, 127.8, 126.1, 125.8, 125.4, 125.1, 123.7, 123.2, 121.8, 121.4, 118.0, 45.3; IR (ATR) 3058, 1625, 1452, 1394, 1352, 1276, 1140, 1046, 995, 757, 686 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{28}H_{17}ClO_2$: 420.0917. Found: 420.0920.

2-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-1*H*-benzo[*f*]chromen-1-one (19a). The title compound (**19a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 185-186 °C. Yield: 63% (127 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 10.2 (1H, d, *J* = 7.8 Hz), 7.96 (1H, d, *J* = 8.4 Hz), 7.87 (1H, d, *J* = 8.4 Hz), 7.84 (1H, t, *J* = 7.8 Hz), 7.65-7.61 (4H, m), 7.47 (1H, d, *J* = 7.2 Hz), 7.38 (1H, s), 7.35-7.29 (4H, m), 7.22-7.19 (2H, m), 5.79 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 179.1, 157.5, 157.2 (d, *J* = 277.9 Hz), 150.3, 144.6, 135.4, 135.2, 131.4 (d, *J* = 4.2 Hz), 130.6, 130.5, 129.3, 128.7, 128.2, 127.7 (d, *J* = 6.3 Hz), 127.3, 127.2, 127.1, 126.6, 125.3, 124.0, 119.8, 117.9 (d, *J* = 1.3 Hz), 117.5, 117.1, 40.7; IR (ATR) 2877, 1590, 1516, 1440, 1415, 1353, 1321, 1256, 1131, 1033, 926, 812, 759, 587 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{28}H_{17}FO_2$: 404.1213. Found: 404.1213.

2-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-1*H*-benzo[*f*]chromen-1-one (19b). The title compound (**19b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 185-186 °C. Yield: 94% (197 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 10.2 (1H, d, *J* = 8.4 Hz), 7.97 (1H, d, *J* = 9.0 Hz), 7.86 (1H, d, *J* = 8.4 Hz), 7.82-7.78 (3H, m), 7.62 (1H, d, *J* = 7.2 Hz), 7.57-7.54 (2H, m), 7.39-7.34 (4H, m), 7.30 (1H, d, *J* = 9.6 Hz), 7.25-7.20 (2H, m), 5.96 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.8, 157.4, 150.6, 145.1, 141.4, 139.9, 135.4, 132.8, 130.6, 130.5, 129.3, 128.9, 128.6, 128.6, 128.2, 127.9, 127.5, 127.1, 127.0, 126.7, 125.3, 123.5, 119.6, 117.5, 117.1, 45.3; IR (ATR) 2874, 1595, 1512, 1440, 1405, 1356, 1304, 1250, 1140, 1004, 928, 815, 755, 584 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{28}H_{17}ClO_2$: 420.0917. Found: 420.0916.

2-(3-Iodo-2-phenyl-1*H*-inden-1-yl)-1*H*-benzo[*f*]chromen-1-one (19c). The title compound (**19c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 185-187 °C. Yield: 42% (107 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 10.14 (1H, d, *J* = 7.8 Hz), 7.97 (1H, d, *J* = 9.0 Hz), 7.85 (1H, d, *J* = 7.8 Hz), 7.78 (1H, t, *J* = 7.8 Hz), 7.72 (2H, d, *J* = 7.8 Hz), 7.61 (1H, t, *J* = 7.8 Hz), 7.48-7.46 (2H, m), 7.40-7.34 (4H, m), 7.29 (1H, d, *J* = 9.0 Hz), 7.26 (1H, t, *J* = 7.2 Hz), 7.19 (1H, t, *J* = 7.8 Hz), 5.92 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.6, 157.4, 150.8, 150.76, 145.6, 145.0, 135.4, 135.0, 130.6, 130.5, 129.3, 128.8, 128.5, 128.4, 128.4, 128.2, 127.6, 127.1, 126.9, 126.6, 125.0, 123.3, 117.5, 117.1, 94.9, 48.1; IR (ATR) 2873, 1595, 1512, 1442, 1406, 1358, 1301, 1251, 1143, 1005, 927, 818, 755, 584 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{28}H_{17}IO_2$: 512.0273. Found: 512.0276.

3-(3-Fluoro-2-phenyl-1*H*-inden-1-yl)-5-(*p*-tolyl)-4*H*-pyran-4-one (20a). The title compound (**20a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 177-178 °C. Yield: 40% (78 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 7.76 (1H, s), 7.58 (2H, d, *J* = 7.8 Hz), 7.55 (1H, d, *J* = 7.8 Hz), 7.48 (2H, d, *J* = 7.2 Hz), 7.43 (1H, d, *J* = 7.8 Hz), 7.38-7.32 (3H, m), 7.27-7.20 (5H, m), 5.59 (1H, brs), 2.39 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.0, 157.1 (d, *J* = 278.1 Hz), 152.4, 152.1, 144.2, 138.5, 135.4, 135.2, 131.3 (d, *J* = 4.3 Hz), 129.2, 129.1, 128.8, 128.6, 128.1, 128.0, 127.7 (d, *J* = 6.1 Hz), 127.5, 127.2 (d, *J* = 4.3 Hz), 124.2 (d, *J* = 1.6 Hz), 119.6, 117.9 (d, *J* = 1.9 Hz), 40.7, 21.2; IR (ATR) 1642, 1611, 1509, 1453, 1328, 1256, 1156, 1086, 1023, 968, 897, 754, 689, 508 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{19}FO_2$: 394.1369. Found: 394.1371.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-5-(*p*-tolyl)-4*H*-pyran-4-one (20b). The title compound (**20b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 137-138 °C. Yield: 87% (178 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 7.76 (2H, d, *J* = 8.4 Hz), 7.72 (1H, s), 7.54 (2H, t, *J* = 8.4 Hz), 7.45 (2H, d *J* = 7.8 Hz), 7.42-7.38 (3H, m), 7.30 (1H, dt, *J* = 6.6, 1.2 Hz), 7.26 (3H, d, *J* = 7.8 Hz), 7.21 (1H, s), 5.78 (1H, brs), 2.39 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.7, 152.3, 152.2, 144.6, 141.3, 139.6, 138.4, 132.7, 129.2, 129.0, 129.0, 128.6, 128.5, 128.0, 128.0, 128.0, 127.6, 127.0, 123.6, 119.6, 45.1, 21.2; IR (ATR) 1642, 1612, 1511, 1455, 1328, 1257, 1155, 1086, 1024, 966, 896, 754, 688, 535, 508 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{19}ClO_2$: 410.1074. Found: 410.1073.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-5-(*p*-tolyl)-4*H*-pyran-4-one (20c). The title compound (**20c**) was prepared according to the general procedure. The product was obtained as viscous oils. Yield: 88% (199 mg). ^1H NMR (600 MHz, $CDCl_3$) δ 7.76 (2H, d, *J* = 7.8 Hz), 7.72

(1H, d, *J* = 1.2 Hz), 7.53 (2H, d, *J* = 7.8 Hz), 7.44 (2H, d, *J* = 6.6 Hz), 7.42-7.40 (2H, m), 7.36-7.31 (1H, m), 7.26-7.25 (3H, m), 7.22 (1H, d, *J* = 7.2 Hz), 7.08-7.04 (1H, m), 5.75 (1H, brs), 2.39 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.6, 157.4, 152.3, 152.2, 143.4, 142.6, 138.5, 133.4, 129.5, 129.2, 129.0, 128.7, 128.6, 128.5, 128.1, 127.6, 127.4, 127.0, 123.5, 120.9, 118.9, 49.4, 21.2; IR (ATR) 1643, 1614, 1514, 1456, 1328, 1257, 1157, 1087, 1025, 967, 898, 764, 698, 578, 537 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{19}BrO_2$: 454.0568. Found: 454.0566.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-5-(4-methoxyphenyl)-4*H*-pyran-4-one (21). The title compound (**21**) was prepared according to the general procedure. The product was obtained as a white solid, mp 160-162 °C. Yield: 91% (193 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.67 (2H, d, *J* = 7.8 Hz), 7.62 (1H, s), 7.46-7.41 (4H, m), 7.33-7.29 (3H, m), 7.21 (1H, t, *J* = 7.8 Hz), 7.16 (1H, t, *J* = 8.4 Hz), 7.11 (1H, s), 6.89 (2H, d, *J* = 8.4 Hz), 5.69 (1H, brs), 3.75 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.8, 159.8, 152.2, 152.0, 144.6, 141.3, 139.6, 132.7, 129.9, 129.0, 128.7, 128.6, 128.5, 128.0, 127.8, 127.6, 127.0, 123.6, 123.2, 119.6, 113.9, 55.3, 45.2; IR (ATR) 3070, 1640, 1608, 1510, 1456, 1335, 1290, 1246, 1180, 1033, 967, 899, 830, 756, 688, 574 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{27}H_{19}ClO_3$: 426.1023. Found: 426.1025.

3-(3-Fluoro-2-phenyl-1*H*-inden-1-yl)-5-(4-fluorophenyl)-4*H*-pyran-4-one (22a). The title compound (**22a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 150-152 °C. Yield: 35% (69 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.76 (1H, s), 7.58-7.57 (3H, m), 7.53 (1H, d, *J* = 7.2 Hz), 7.43 (1H, d, *J* = 7.2 Hz), 7.38-7.32 (3H, m), 7.28 (1H, s), 7.25-7.20 (3H, m), 7.14 (2H, t, *J* = 9.0 Hz), 5.57 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.9, 163.0 (d, *J* = 247.2 Hz), 157.2 (d, *J* = 278.2 Hz), 152.6, 152.3, 144.0, 135.3, 131.3 (d, *J* = 4.6 Hz), 130.6, 130.5, 128.8, 128.3, 128.2, 127.7 (d, *J* = 6.3 Hz), 127.6, 127.3 (d, *J* = 5.7 Hz), 127.0 (d, *J* = 3.4 Hz), 124.1, 119.6, 118.0 (d, *J* = 2.1 Hz), 115.6 (d, *J* = 21.5 Hz), 40.7; IR (ATR) 1643, 1615, 1510, 1453, 1318, 1256, 1167, 1077, 1026, 968, 899, 766, 699, 588, 547 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{16}F_2O_2$: 398.1118. Found: 398.1118.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-5-(4-fluorophenyl)-4*H*-pyran-4-one (22b). The title compound (**22b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 184-185 °C. Yield: 86% (178 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.64 (2H, d, *J* = 7.8 Hz), 7.60 (1H, s), 7.44-7.42 (4H, m), 7.31-7.27 (3H, m), 7.20 (1H, t, *J* = 7.2 Hz), 7.14 (1H, t, *J* = 7.2 Hz), 7.12 (1H, s), 7.02 (2H, t, *J* = 7.8 Hz), 5.65 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.5, 162.9 (d, *J* = 247.2 Hz), 152.5 (d, *J* = 4.5 Hz), 144.4, 141.3, 139.5, 132.6, 130.5 (d, *J* = 7.9 Hz), 129.1, 128.6, 128.5, 128.2, 128.1, 128.0, 127.6, 127.0, 126.9 (d, *J* = 3.4 Hz), 123.5, 119.6, 115.5, 115.4, 45.1; IR (ATR) 1645, 1610, 1512, 1454, 1318, 1257, 1156, 1089, 1026, 977, 899, 766, 699, 598, 547 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{16}ClFO_2$: 414.0823. Found: 414.0826.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-5-(4-fluorophenyl)-4*H*-pyran-4-one (22c). The title compound (**22c**) was prepared according to the general procedure. The product was obtained as a white solid, mp 178-179 °C. Yield: 89% (203 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.66 (2H, d, *J* = 7.2 Hz), 7.62 (1H, s), 7.45-7.41 (4H, m), 7.33-7.30 (3H, m), 7.23 (1H, t, *J* = 7.2 Hz), 7.17-7.14 (2H, m), 7.03 (2H, t, *J* = 8.4 Hz), 5.63 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 176.4, 162.9 (d, *J* = 247.2 Hz), 152.4, 144.6, 143.3, 142.6, 133.4, 130.5 (d, *J* = 8.1 Hz), 128.7, 128.5, 128.2, 128.1, 127.9, 127.7, 127.0, 126.9 (d, *J* = 3.3 Hz), 123.4, 120.9, 119.0, 115.5, 115.4, 46.5; IR (ATR) 1644, 1614, 1512, 1457, 1318, 1256, 1137, 1086, 1023, 977, 878, 754, 688, 579 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{16}BrFO_2$: 458.0318. Found: 458.0316.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-4*H*-thiochromen-4-one (23a). The title compound (**23a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 174-176 °C. Yield: 86% (165 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.66 (1H, s), 7.73 (2H, d, *J* = 7.8 Hz), 7.55-7.54 (2H, m), 7.50 (1H, d, *J* = 7.8 Hz), 7.47-7.45 (1H, m), 7.38-7.34 (2H, m), 7.32 (2H, t, *J* = 7.8 Hz), 7.24-7.22 (1H, m), 7.19-7.17 (2H, m), 6.13 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.9, 145.6, 144.5, 142.8, 137.1, 134.5, 133.8, 133.6, 131.6, 131.2, 129.1, 128.7, 128.4, 128.0, 127.7, 127.5, 126.9, 126.5, 123.3, 120.9, 118.8, 50.8; IR (ATR) 3067, 1759, 1637, 1607, 1585, 1582, 1452, 1405, 1343, 1231, 1092, 987, 931, 759, 685, 592, 521 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}ClOS$: 386.0532. Found: 386.0532.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-4*H*-thiochromen-4-one (23b). The title compound (**23b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 165-166 °C. Yield: 84% (180 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.61 (1H, s), 7.67 (2H, d, *J* = 7.8 Hz), 7.50-7.48 (2H, m), 7.45 (1H, d, *J* = 7.8 Hz), 7.41-7.40 (1H, m), 7.33 (1H, d, *J* = 7.2 Hz), 7.30-7.25 (3H, m), 7.17-7.11 (3H, m), 6.08 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 179.0, 145.4, 141.5, 140.7, 137.2, 134.5, 134.0, 132.9, 131.6, 131.2, 129.1, 129.0, 128.5, 128.5, 127.9, 127.7, 127.4, 126.9, 126.5, 123.4, 119.6, 49.5; IR (ATR) 3167, 1752, 1637, 1601, 1585, 1581, 1453, 1405, 1343, 1231, 1092, 987, 931, 756, 681, 593, 522 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}BrOS$: 430.0027. Found: 430.0024.

6-Chloro-3-(3-chloro-2-phenyl-1*H*-inden-1-yl)-4*H*-thiochromen-4-one (24a). The title compound (**24a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 194-195 °C. Yield: 84% (176 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.53 (1H, s), 7.60 (2H, d, *J* = 7.8 Hz), 7.40 (1H, d, *J* = 7.2 Hz), 7.36 (1H, dd, *J* = 8.4, 2.4 Hz), 7.26-7.19 (5H, m), 7.11-7.04 (3H, m), 5.98 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.9, 145.0, 141.5, 140.5, 135.2, 134.5, 134.3, 134.1, 132.7, 132.6, 131.6, 129.2, 128.7, 128.5, 128.5, 128.4, 127.9, 127.5, 126.9, 123.3, 119.6, 49.4; IR (ATR) 3061, 1752, 1617, 1617, 1586, 1584, 1452, 1405, 1343, 1231, 1093, 986, 931, 759, 684, 592, 520 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}Cl_2OS$: 420.0142. Found: 420.0144.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-6-chloro-4*H*-thiochromen-4-one (24b). The title compound (**24b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 180-181 °C. Yield: 87% (201 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.63 (1H, s), 7.71 (2H, d, *J* = 7.2 Hz), 7.50 (2H, d, *J* = 8.4 Hz), 7.40 (1H, dd, *J* = 6.6, 1.8 Hz), 7.37-7.31 (4H, m), 7.25-7.17 (3H, m), 6.08 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.9, 144.3, 142.8, 135.2, 134.5, 134.3, 134.0, 133.5, 132.7, 131.6, 128.7, 128.6, 128.5, 128.1, 128.0, 127.6, 127.0, 123.3, 122.2, 121.0, 119.0, 50.7; IR (ATR) 3077, 1753, 1632, 1606, 1584, 1581, 1453, 1402, 1313, 1230, 1091, 977, 932, 759, 684, 592, 521 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}BrClOS$: 463.9637. Found: 463.9641.

3-(2-Butyl-3-chloro-1*H*-inden-1-yl)-4*H*-thiochromen-4-one (25a). The title compound (**25a**) was prepared according to the general procedure. The product was obtained as viscous oils. Yield: 81% (148 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.69 (1H, s), 7.61-7.54 (3H, m), 7.38 (1H, d, *J* = 7.8 Hz), 7.32-7.27 (2H, m), 7.13 (2H, t, *J* = 7.8 Hz), 5.53 (1H, brs), 2.71-2.66 (1H, m), 2.13-2.08 (1H, m), 1.56-1.42 (2H, m), 1.37-1.24 (2H, m), 0.86 (3H, t, *J* = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.9, 145.5, 145.3, 141.6, 137.1, 134.0, 133.8, 131.6, 131.2, 129.2, 128.6, 127.8, 127.1, 126.5, 125.9, 123.4, 118.6, 49.0, 30.7, 26.4, 22.4, 13.7; IR (ATR) 2928, 2863, 1725, 1641, 1462, 1345, 1275, 1216, 1143, 1100, 989, 860, 759, 602 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}ClOS$: 366.0845. Found: 366.0844.

3-(3-Bromo-2-butyl-1*H*-inden-1-yl)-4*H*-thiochromen-4-one (25b). The title compound (**25b**) was prepared according to the general procedure. The product was obtained as viscous oils. Yield: 79% (161 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.68 (1H, d, J = 7.8 Hz), 7.62-7.56 (3H, m), 7.35 (1H, d, J = 7.8 Hz), 7.31 (1H, t, J = 7.2 Hz), 7.25 (1H, d, J = 7.2 Hz), 7.12 (2H, t, J = 7.8 Hz), 5.52 (1H, brs), 2.68-2.63 (1H, m), 2.14-2.09 (1H, m), 1.55-1.41 (2H, m), 1.36-1.26 (2H, m), 0.86 (3H, t, J = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 178.9, 148.9, 145.8, 142.8, 137.1, 134.1, 133.7, 131.7, 131.2, 129.2, 127.8, 127.2, 126.6, 126.0, 123.3, 119.8, 118.9, 49.9, 30.8, 28.0, 22.5, 13.8; IR (ATR) 2927, 2867, 1729, 1642, 1452, 1355, 1276, 1217, 1142, 1103, 987, 862, 757, 612 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}BrOS$: 410.0340. Found: 410.0342.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-2*H*-chromen-2-one (26a). The title compound (**26a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 214-215 °C. Yield: 83% (153 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (2H, d, J = 7.2 Hz), 7.55 (1H, d, J = 7.8 Hz), 7.52 (1H, d, J = 7.2 Hz), 7.41-7.36 (4H, m), 7.27-7.24 (3H, m), 7.14 (1H, d, J = 7.2 Hz), 7.10 (1H, d, J = 7.8 Hz), 7.07 (1H, s), 5.64 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.1, 153.0, 144.1, 141.6, 139.9, 138.8, 132.7, 131.1, 129.4, 128.6, 128.5, 128.1, 127.8, 127.6, 127.1, 127.0, 124.2, 123.3, 119.7, 119.1, 116.3, 49.3; IR (ATR) 3070, 1640, 1608, 1510, 1456, 1335, 1290, 1246, 1180, 1033, 967, 899, 830, 756, 688, 574, 540 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}ClO_2$: 370.0761. Found: 370.0762.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-2*H*-chromen-2-one (26b). The title compound (**26b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 198-199 °C. Yield: 86% (178 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.67 (2H, d, J = 7.8 Hz), 7.43 (1H, d, J = 7.2 Hz), 7.39 (1H, d, J = 7.8 Hz), 7.30-7.25 (4H, m), 7.17-7.11 (3H, m), 7.03 (1H, d, J = 7.8 Hz), 6.98 (2H, t, J = 7.2 Hz), 5.50 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.0, 152.9, 144.3, 143.6, 142.8, 138.9, 133.3, 131.1, 128.6, 128.5, 128.1, 127.8, 127.5, 127.1, 126.8, 124.2, 123.2, 121.0, 119.3, 119.0, 116.3, 50.6; IR (ATR) 3072, 1641, 1606, 1513, 1457, 1337, 1293, 1242, 1180, 1033, 964, 890, 832, 756, 689, 574, 542 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{15}BrO_2$: 414.0255. Found: 414.0257.

3-(3-Chloro-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-2*H*-chromen-2-one (27a). The title compound (**27a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 220-221 °C. Yield: 82% (163 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.67 (2H, d, J = 7.8 Hz), 7.42-7.37 (2H, m), 7.35 (1H, s), 7.26 (1H, d, J = 8.4 Hz), 7.20-7.17 (3H, m), 7.14 (1H, d, J = 7.2 Hz), 7.10-7.07 (2H, m), 5.59 (1H, brs), 2.35 (3H, s), 2.30 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.1, 152.9, 144.3, 139.1, 138.8, 138.6, 137.8, 137.1, 131.0, 129.9, 129.3, 128.6, 128.4, 128.3, 127.6, 127.4, 124.1, 124.1, 119.3, 119.2, 116.2, 48.9, 21.4, 21.1; IR (ATR) 3071, 1640, 1603, 1511, 1453, 1331, 1290, 1246, 1180, 1035, 968, 899, 831, 756, 683, 574, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{19}ClO_2$: 398.1074. Found: 398.1075.

3-(3-Bromo-6-methyl-2-(*p*-tolyl)-1*H*-inden-1-yl)-2*H*-chromen-2-one (27b). The title compound (**27b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 205-206 °C. Yield: 85% (187 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.56 (2H, d, J = 7.2 Hz), 7.29-7.25 (2H, m), 7.21 (1H, s), 7.13 (1H, d, J = 8.4 Hz), 7.09-7.03 (4H, m), 6.98 (1H, t, J = 7.2 Hz), 6.95 (1H, s), 5.45 (1H, brs), 2.25 (3H, s), 2.19 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.2, 152.9, 144.5, 142.5, 140.3, 138.7, 137.9, 137.0, 131.0, 130.6, 129.2, 128.5, 128.4, 127.5, 127.2, 124.1, 124.0, 120.5, 119.2, 118.5, 116.2, 50.2, 21.4, 21.2; IR (ATR) 3075, 1640, 1603, 1511, 1456, 1335, 1291, 1246, 1180, 1023, 977, 890, 835, 759, 689, 574, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{19}BrO_2$: 442.0568. Found: 442.0572.

3-(2-Butyl-3-chloro-1*H*-inden-1-yl)-2*H*-chromen-2-one (28a). The title compound (**28a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 123-124 °C. Yield: 80% (140 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.47 (1H, dt, J = 8.4, 1.8 Hz), 7.40 (1H, d, J = 7.8 Hz), 7.38 (1H, d, J = 7.2 Hz), 7.35-7.32 (2H, m), 7.28 (1H, d, J = 7.8 Hz), 7.21-7.17 (2H, m), 7.06 (1H, s), 5.02 (1H, brs), 2.77-2.72 (1H, m), 2.19-2.15 (1H, m), 1.60-1.45 (2H, m), 1.40-1.29 (2H, m), 0.89 (3H, t, J = 7.8 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.1, 153.1, 144.2, 144.1, 141.5, 138.5, 131.2, 129.1, 127.6, 127.5, 126.9, 126.1, 124.3, 123.2, 119.1, 118.8, 116.4, 48.7, 30.7, 26.4, 22.4, 13.7; IR (ATR) 2955, 1706, 1604, 1454, 1376, 1247, 1170, 1058, 937, 894, 754, 654, 614, 527 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}ClO_2$: 350.1074. Found: 350.1071.

3-(3-Bromo-2-butyl-1*H*-inden-1-yl)-2*H*-chromen-2-one (28b). The title compound (**28b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 124-125 °C. Yield: 79% (155 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.47 (1H, dt, J = 8.4, 1.8 Hz), 7.38-7.32 (4H, m), 7.28 (1H, d, J = 7.2 Hz), 7.21-7.16 (2H, m), 7.03 (1H, s), 5.01 (1H, brs), 2.74-2.69 (1H, m), 2.19-2.14 (1H, m), 1.59-1.53 (1H, m), 1.50-1.44 (1H, m), 1.38-1.28 (2H, m), 0.88 (3H, t, J = 7.8 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.0, 153.1, 147.7, 144.5, 142.7, 138.5, 131.4, 127.6, 127.6, 126.8, 126.2, 124.4, 123.2, 120.0, 119.4, 119.1, 116.4, 49.6, 30.8, 28.0, 22.5, 13.7; IR (ATR) 2956, 1706, 1603, 1453, 1377, 1248, 1171, 1053, 936, 899, 755, 654, 613, 528 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{22}H_{19}BrO_2$: 394.0568. Found: 394.0565.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-4-chloro-2*H*-chromen-2-one (29). The title compound (**29**) was prepared according to the general procedure. The product was obtained as a white solid, mp 195-196 °C. Yield: 78% (174 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.93 (1H, d, J = 8.4 Hz), 7.64 (2H, d, J = 8.4 Hz), 7.55 (1H, d, J = 7.8 Hz), 7.48 (1H, t, J = 7.8 Hz), 7.42 (1H, t, J = 7.5 Hz), 7.35-7.31 (3H, m), 7.27-7.21 (3H, m), 7.15 (1H, d, J = 8.2 Hz), 5.75 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 161.2, 155.0, 151.4, 144.1, 144.0, 142.1, 140.8, 133.9, 132.3, 128.7, 128.6, 128.3, 128.1, 127.9, 126.4, 124.7, 121.9, 121.1, 119.1, 118.3, 116.5, 55.3; IR (ATR) 3071, 1642, 1601, 1500, 1466, 1334, 1291, 1241, 1187, 1034, 968, 890, 831, 755, 687, 575, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}BrClO_2$: 447.9866. Found: 447.9864.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)quinolin-2(1*H*)-one (30). The title compound (**30**) was prepared according to the general procedure. The product was obtained as a white solid, mp 245-247 °C. Yield: 84% (154 mg). ^{1}H NMR (600 MHz, $CDCl_3$, DMSO) δ 11.72 (1H, brs), 7.76 (2H, d, J = 7.2 Hz), 7.43-7.41 (2H, m), 7.28-7.20 (5H, m), 7.14-7.10 (3H, m), 6.95-6.89 (2H, m), 5.80 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$, DMSO) δ 162.3, 144.7, 140.7, 140.4, 137.2, 134.8, 132.3, 130.4, 129.0, 127.8, 127.6, 127.6, 127.0, 126.6, 126.5, 126.1, 122.7, 121.1, 118.8, 118.6, 114.6, 47.8; IR (ATR) 3076, 1643, 1605, 1518, 1447, 1343, 1290, 1249, 1184, 1034, 966, 881, 831, 758, 681, 572, 540 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{16}ClNO$: 369.0920. Found: 369.0922.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-1-methylquinolin-2(1*H*)-one (31a). The title compound (**31a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 174-175 °C. Yield: 84% (160 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.82 (2H, d, J = 7.8 Hz), 7.56-7.53 (2H, m), 7.40-7.33 (4H, m), 7.22-7.17 (4H, m), 7.06-7.01 (2H, m), 6.00 (1H, brs), 3.79 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.5, 145.4, 141.5, 140.9, 138.9, 134.7, 133.1, 130.8, 129.9, 128.6, 128.5, 128.3, 128.3, 127.7, 127.3, 126.7, 123.4, 121.9, 120.2, 119.4, 113.7, 49.3, 30.0; IR (ATR) 3073, 1644, 1602, 1511, 1457, 1333, 1291, 1241, 1181, 1032, 966, 891, 831, 757, 685, 573, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{18}ClNO$: 383.1077. Found: 383.1076.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-1-methylquinolin-2(1*H*)-one (31b). The title compound (**31b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 172-173 °C. Yield: 83% (177 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.82 (2H, d, J = 7.8 Hz), 7.53 (1H, d, J = 7.8 Hz), 7.50 (1H, d, J = 7.8 Hz), 7.41-7.33 (4H, m), 7.24-7.19 (4H, m), 7.12-7.03 (2H, m), 5.97 (1H, brs), 3.78 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.5, 145.6, 144.7, 142.7, 138.9, 134.9, 133.8, 130.6, 129.9, 128.7, 128.4, 128.3, 127.89, 127.3, 126.7, 123.3, 121.9, 120.7, 120.2, 118.5, 113.7, 50.6, 30.1; IR (ATR) 3075, 1643, 1601, 1517, 1455, 1331, 1290, 1248, 1187, 1031, 967, 890, 834, 756, 683, 572, 540 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{25}H_{18}BrNO$: 427.0572. Found: 427.0576.

3-(3-Chloro-2-phenyl-1*H*-inden-1-yl)-1,6-dimethylquinolin-2(1*H*)-one (32a). The title compound (**32a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 173-174 °C. Yield: 80% (158 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.81 (2H, d, J = 7.8 Hz), 7.55-7.52 (2H, m), 7.38-7.33 (3H, m), 7.25-7.20 (3H, m), 7.16 (1H, d, J = 8.4 Hz), 7.01 (2H, s), 6.00 (1H, brs), 3.80 (3H, s), 2.26 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.5, 145.5, 141.6, 141.0, 137.1, 134.5, 133.2, 131.5, 131.2, 130.7, 128.6, 128.4, 128.2, 127.7, 127.3, 126.8, 123.4, 120.3, 119.4, 113.7, 49.4, 30.1, 20.3; IR (ATR) 3073, 1644, 1602, 1511, 1457, 1333, 1291, 1241, 1181, 1032, 966, 891, 831, 757, 685, 573, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{20}ClNO$: 397.1233. Found: 397.1235.

3-(3-Bromo-2-phenyl-1*H*-inden-1-yl)-1,6-dimethylquinolin-2(1*H*)-one (32b). The title compound (**32b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 171-172 °C. Yield: 78% (171 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.80 (2H, d, J = 7.8 Hz), 7.53 (1H, d, J = 7.8 Hz), 7.50 (1H, d, J = 6.0 Hz), 7.38-7.33 (3H, m), 7.25-7.16 (5H, m), 7.03 (1H, m), 5.96 (1H, brs), 3.79 (3H, s), 2.27 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.4, 145.8, 144.8, 142.8, 137.1, 134.7, 133.9, 131.5, 131.2, 130.5, 128.7, 128.3, 128.3, 127.8, 127.3, 126.8, 123.4, 120.7, 120.3, 118.5, 113.7, 50.7, 30.1, 20.3; IR (ATR) 3071, 1644, 1602, 1518, 1456, 1330, 1291, 1247, 1186, 1032, 966, 891, 832, 757, 680, 571, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{20}BrNO$: 441.0728. Found: 441.0728.

1-Benzyl-3-(3-chloro-2-phenyl-1*H*-inden-1-yl)quinolin-2(1*H*)-one (33a). The title compound (**33a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 175-176 °C. Yield: 81% (185 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.71 (2H, d, J = 7.8 Hz), 7.42-7.38 (2H, m), 7.22-7.17 (3H, m), 7.12-7.02 (7H, m), 7.00-6.94 (4H, m), 6.76 (1H, t, J = 7.2 Hz), 5.94 (1H, brs), 5.53-5.37 (2H, m); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.76, 145.4, 141.7, 141.4, 138.3, 136.1, 135.3, 133.1, 130.7, 129.9, 128.6, 128.6, 128.4, 128.3, 127.7, 127.3, 127.1, 126.8, 126.4, 126.2, 123.3, 121.9, 120.4, 119.4, 114.4, 49.2, 46.3; IR (ATR) 3074, 1641, 1603, 1510, 1454, 1331, 1290, 1243, 1184, 1031, 967, 890, 831, 754, 684, 571, 540 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{31}H_{22}ClNO$: 459.1390. Found: 459.1388.

1-Benzyl-3-(3-bromo-2-phenyl-1*H*-inden-1-yl)quinolin-2(1*H*)-one (33b). The title compound (**33b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 170-171 °C. Yield: 72% (181 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.87 (2H, d, J = 7.8 Hz), 7.59 (1H, d, J = 7.8 Hz), 7.53 (1H, d, J = 7.8 Hz), 7.43 (1H, t, J = 7.8 Hz), 7. 38 (2H, t, J = 7.8 Hz), 7.38-7.23 (9H, m), 7.18-7.16 (2H, m), 7.03 (1H, t, J = 7.2 Hz), 6.09 (1H, brs), 5.74-5.60 (2H, m); ^{13}C NMR (150 MHz, $CDCl_3$) δ 162.6, 145.3, 143.1, 139.7, 138.4, 136.1, 133.8, 130.6, 130.0, 128.8, 128.7, 128.5, 128.3, 127.9, 127.4, 127.2, 126.8, 126.5, 126.3, 122.0, 120.8, 118.4, 115.0, 114.6, 50.6, 46.4, 35.7; IR (ATR) 3075, 1646, 1601, 1511, 1456, 1321, 1291, 1241, 1185, 1034, 965, 896, 834, 754, 683, 577, 541 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{31}H_{22}BrNO$: 503.0885. Found: 503.0882.

3-(2,3-Diphenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (34a). The title compound (**34a**) was prepared according to the general procedure. The product was obtained as a white solid, mp 212-214 °C. Yield: 85% (175 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.32 (1H, d, J = 7.2 Hz), 7.59 (1H, dt, J = 7.2, 1.8 Hz), 7.54 (1H, d, J = 7.2 Hz), 7.44-7.36 (7H, m), 7.28 (1H, d, J = 8.4 Hz), 7.25-7.24 (2H, m), 7.20-7.15 (3H, m), 7.13-7.10 (2H, m), 7.09-7.06 (1H, m), 5.84 (1H, brs); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.6, 156.2, 153.1, 147.1, 144.7, 143.1, 141.7, 135.3, 134.6, 133.4, 129.4, 129.1, 128.8, 128.2, 127.6, 127.1, 127.0, 125.9, 125.9, 125.0, 123.9, 123.7, 123.1, 120.7, 118.0, 46.2; IR (ATR) 3016, 1628, 1461, 1391, 1277, 1212, 1138, 849, 754, 692 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{30}H_{20}O_2$: 412.1463. Found: 412.1460.

3-(2-Phenyl-3-(*p*-tolyl)-1*H*-inden-1-yl)-4*H*-chromen-4-one (34b). The title compound (**34b**) was prepared according to the general procedure. The product was obtained as a white solid, mp 224-225 °C. Yield: 87% (185 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.32 (1H, d, J = 8.4 Hz), 7.58 (1H, t, J = 8.4 Hz), 7.54 (1H, d, J = 7.8 Hz), 7.39 (1H, t, J = 7.8 Hz), 7.35 (1H, s), 7.30-7.21 (9H, m), 7.17-7.14 (1H, m), 7.13 (2H, dt, J = 6.6, 1.2 Hz), 7.7.09-7.06 (1H, m), 5.83 (1H, brs), 2.41 (3H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.7, 156.2, 153.1, 147.1, 144.8, 142.7, 141.7, 137.3, 134.7, 133.4, 132.2, 129.5, 129.2, 129.1, 128.2, 127.0, 126.9, 125.9, 125.8, 125.0, 123.9, 123.6, 123.2, 120.7, 118.0, 46.1, 21.3; IR (ATR) 3017, 1628, 1462, 1395, 1278, 1213, 1134, 845, 753, 691 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{31}H_{22}O_2$: 426.1620. Found: 426.1622.

3-(3-(Furan-2-yl)-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (35). The title compound (**35**) was prepared according to the general procedure. The product was obtained as a white solid, mp 164-165 °C. Yield: 89% (178 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.19 (1H, d, J = 7.8 Hz), 7.69 (1H, d, J = 7.8 Hz), 7.50 (1H, dt, J = 7.2, 1.8 Hz), 7.42-7.39 (2H, m), 7.31-7.24 (5H, m), 7.21-7.16 (3H, m), 7.13-7.09 (2H, m), 6.40-6.38 (2H, m), 5.72 (1H, brs), ^{13}C NMR (150 MHz, $CDCl_3$) δ 177.3, 156.2, 153.4, 149.1, 146.9, 144.9, 142.5, 141.8, 135.2, 133.4, 130.2, 129.0, 128.3, 127.5, 127.2, 126.0, 125.9, 125.0, 123.8, 123.6, 122.8, 121.6, 118.0, 111.1, 109.9, 47.1; IR (ATR) 3070, 1626, 1568, 1452, 1395, 1351, 1251, 1153, 1018, 937, 804, 745, 698, 592 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{28}H_{18}O_3$: 402.1256. Found: 402.1258.

3-(3-Ethoxy-2-phenyl-1*H*-inden-1-yl)-4*H*-chromen-4-one (36). The title compound (**36**) was prepared according to the general procedure. The product was obtained as a red colour viscous oils. Yield: 55% (104 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.05 (1H, dd, J = 7.8, 1.2 Hz), 7.93 (1H, d, J = 8.4 Hz), 7.48-7.35 (6H, m), 7.21 (1H, t, J = 7.2 Hz), 7.15 (1H, d, J = 6.6 Hz), 7.09-7.05 (2H, m), 6.88 (1H, s), 6.81 (1H, d, J = 8.4 Hz), 5.67 (1H, s), 3.39-3.33 (1H, m), 2.82-2.77 (1H, m), 0.97 (3H, t, J = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 185.4, 156.4, 145.8, 142.7, 141.9, 139.1, 137.6, 135.9, 135.4, 133.0, 130.1, 127.9, 127.7, 127.1, 126.9, 125.1, 123.2, 121.8, 121.1, 117.5, 100.1, 64.3, 42.8, 14.8; IR (ATR) 2980, 1669, 1603, 1458, 1293, 1205, 1081, 985, 927, 746, 699 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{26}H_{20}O_3$: 380.1412. Found: 380.1414.

3-(1-Oxo-2-phenyl-1*H*-inden-3-yl)-4*H*-chromen-4-one (37). The title compound (**37**) was prepared according to the general procedure. The product was obtained as a orange solid, mp 205-206 °C. Yield: 67% (117 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.30 (1H, d, J = 8.4 Hz), 7.79 (1H, s), 7.72 (1H, dt, J = 7.8, 1.2 Hz), 7.55 (1H, d, J = 7.2 Hz), 7.49-7.46 (2H, m), 7.37-7.33 (3H, m), 7.30 (2H, d, J = 6.6 Hz), 7.27-7.23 (2H, m), 6.99 (1H, d, J = 7.2 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 195.6, 175.6, 156.1, 154.9, 147.6, 144.7, 135.8, 134.2, 133.9, 130.2, 129.9, 129.5, 128.9, 128.4, 128.1, 126.3, 125.8, 124.0, 122.9, 121.7, 118.8, 118.2; IR (ATR) 1704, 1591, 1453, 1336, 1276, 1129, 1066, 927, 857, 753 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{24}H_{14}O_3$: 350.0943. Found: 350.0945.

(2*R*)-2,3-Diphenyl-2,3-dihydro-1*H*-inden-1-one (40). The title compound (**40**) was prepared according to the general procedure. The product was obtained as viscous oils. Yield: 66% (187 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.91 (1H, d, J = 7.8 Hz), 7.64 (1H, dt, J = 7.2, 1.2 Hz), 7.49 (1H, t, J = 7.8 Hz), 7.34-7.27 (7H, m), 7.13-7.10 (4H, m), 4.60 (1H, d, J = 4.8 Hz), 3.84 (1H, d, J = 4.8 Hz); ^{13}C NMR (150 MHz, $CDCl_3$) δ 205.1, 156.0, 142.4, 138.4, 136.0, 135.3, 128.8, 128.8, 128.7, 128.2, 128.2, 127.8, 127.1, 126.6, 123.9, 64.5, 54.7; IR (ATR) 3027, 1711, 1598, 1492, 1452, 1279, 1214, 1033, 752, 686 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_{21}H_{16}O$: 284.1201. Found: 284.1203.

2,2-Difluoro-4,6-dimethyl-2*H*-dioxaborinine (44). The title compound (**44**) was prepared according to the general procedure. The product was obtained as brown viscous oils. Yield: 83% (122 mg). ^{1}H NMR (600 MHz, $CDCl_3$) δ 5.96 (1H, s), 2.26 (6H, s); ^{13}C NMR (150 MHz, $CDCl_3$) δ 192.3, 101.8, 24.0; IR (ATR) 3192, 2261, 1550, 1380, 1359, 1138, 1074, 812, 506 cm^{-1}; HRMS *m/z* (M^+) calcd for $C_5H_7BF_2O_2$: 148.0507. Found: 148.0505.

Acknowledgements

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (2018R1A2B2004432), the Priority Research Centers Program (2014R1A6A1031189), and the Korean Ministry of Education, Science and Technology (2012M3A7B4049675).

References

[1] a) N. J. Clegg, S. Paruthiyil, D. C. Leitman, T. S. Scanlan, *J. Med. Chem*. **2005**, *48*, 5989; b) H. Gao, J. A. Katzenellenbogen, R. Garg, C. Hansch, *Chem. Rev*. **1999**, *99*, 723; c) W. Liu, M. Buck, N. Chen, M. Shang, N. J. Taylor, J. Asoud, X. Wu, B. B. Hasinoff, G. I. Dmitrienko, *Org. Lett*. **2007**, *9*, 2915; d) J. H. Ahn, M. S. Shin, S. H. Jung, S. K. Kang, K. R. Kim, S. D. Rhee, W. H. Jung, S. D. Yang, S. J. Kim, J. R. Woo, J. H. Lee, H. G. Cheon, S. S. Kim, *J. Med. Chem*. **2006**, *49*, 4781; e) M. A. Ernst-Russell, C. L. L. Chai, J. H. Wardlaw, J. A. Elix, *J. Nat. Prod*. **2000**, *63*, 129; f) B.-J. Li, H.-Y. Wang, Q.-L. Zhu, Z.-J. Shi, *Angew. Chem.* **2012**, *124*, 4014*; Angew. Chem., Int. Ed*. **2012**, *51*, 3948.

[2] a) R. Leino, P. Lehmus, A. Lehtonen, *Eur. J. Inorg. Chem*. **2004**, 3201; b) J. Barberá, O. A. Rakitin, M. Blanca Ros, T. Torroba, *Angew. Chem.* **1998**, *110*, 308; *Angew. Chem., Int. Ed*. **1998**, *37*, 296.

[3] a) A. Odedra, S. Datta, R.-S. Liu, *J. Org. Chem*. **2007**, *72*, 3289; b) J. Panteleev, R. Y. Huang, E. K. J. Lui, M. Lautens, *Org. Lett*. **2011**, *13*, 5314; c) H.-T. Zhu, K.-G. Ji, F. Yang, L.-J. Wang, S.-C. Zhao, S. Ali, X.-Y. Liu, Y.-M. Liang, *Org. Lett*. **201**1, *13*, 684.

[4] a) S. Sueki, Y. Kuninobu, *Chem. Commun*. **2015**, *51*, 7685; b) M. Ueda, T. Ueno, Y. Suyama, I. Ryu, *Chem. Commun*. **2016**, *52*, 13237; c) P. P. Kaishap, G. Duarah, B. Sarma, D. Chetia, S. Gogoi, *Angew. Chem.* **2018**, *130*, 465*; Angew. Chem., Int. Ed*. **2018**, *57*, 456; d) Y. Zhu, G. Yin, D. Hong, P. Lu, Y. Wang, *Org. Lett*. **2011**, *13*, 1024; e) X. Su, P. Wu, W. Liu, C. Chen, *Org. Chem. Front*. **2018**, *5*, 1165.

[5] P. Morán-Poladura, E. Rubio, J. M. González, *Angew. Chem.* **2015**, *127*, 3095*; Angew. Chem., Int. Ed*. **2015**, *54*, 3052.

[6] Z. A. Khan, T. Wirth, *Org. Lett*. **2009**, *11*, 229.

[7] S. Ye, K. Gao, H. Zhou, X. Yang, J. Wu, *Chem. Commun.* **2009**, 5406.

[8] R. Sanz, A. Martínez, P. García-García, M. A. Fernández-Rodríguez, M. A. Rashid, F. Rodríguez, *Chem. Commun*. **2010**, *46*, 7427.

[9] a) K. Müller, C. Faeh, F. Diederich, *Science* **2007**, *317*, 1881; b) S. Purser, P. R. Moore, S. Swallow, V. Gouverneur, *Chem. Soc. Rev*. **2008**, *37*, 320; c) S. M. Ametamey, M. Honer, P. A. Schubiger, *Chem. Rev*. **2008**, *108*, 1501; d) D. E. Yerien, S. Bonesi, A. Postigo, *Org. Biomol. Chem*. **2016**, *14*, 8398.

[10] a) P. A. Champagne, J. Desroches, J.-D. Hamel, M. Vandamme, J.-F. Paquin, *Chem. Rev*. **2015**, *115*, 9073; b) T. Furuya, A. S. Kamlet, T. Ritter, *Nature* **2011**, *473*, 470. c) P. Alonso, P. Pardo, R. Fontaneda, F. J. Fananás, F. Rodríguez, *Chem. Eur. J.* **2017**, *23*, 13158; d) A. Venkateswarlu, M. Kanakaraju, A. C. Kunwar, Y. V. R. Reddy, B. V. S. Reddy, *Eur. J. Org. Chem.* **2015**, *24*, 5389; e) M.-C. P. Yeh, H.-F. Chen, Y.-Y. Huang, Y.-T. Weng, *J. Org. Chem.* **2015**, *80*, 10892; f) Y. Xiang, Z. Li, L.-N. Wang, Z.-X. Yu, *J. Org. Chem.* **2018**, *83*, 7633; g) P. Alonso, P. Pardo, F. J. Fananás, F. Rodríguez, *Chem. Commun*. **2014**, *50*, 14364; h) G. Pupo, A. C. Vicini, D. M. H. Ascough, F. Ibba, K. E. Christensen, A. L. Thompson, J. M. Brown, R. S. Paton, V. Gouverneur, *J. Am. Chem. Soc.* **2019**, *141*, 2878; i) E. A. Meucci, A. Ariafard, A. J. Canty, J. W. Kampf, M. S. Sanford, *J. Am. Chem. Soc.* **2019**, *141*, 13261.

[11] Reviews: a) T. Xu, X. Mu, H. Peng, G. Liu, *Angew. Chem.* **2011**, *123*, 8326*; Angew. Chem., Int*. Ed. **2011**, *50*, 8176; b) H. Peng, G. Liu, *Org. Lett*. **2011**, *13*, 772; c) J. A. Akana, K. X. Bhattacharyya, P. Müller, J. P. Sadighi, *J. Am. Chem. Soc*. **2007**, *129*, 7736; d) M. Schuler, F. Silva, C. Bobbio, A. Tessier, V. Gouverneur, *Angew. Chem*. **2008**, *120*, 8045; *Angew. Chem., Int. Ed*. **2008**, *47*, 7927; e) J. Qian, Y. Liu, J. Zhu, B. Jiang, Z. Xu, *Org. Lett*. **2011**, *13*, 4220; f) T. de Haro, C. Nevado, *Chem. Commun*. **2011**, *47*, 248; g) T. Liang, C. N. Neumann, T. Ritter, *Angew. Chem.* **2013**, *125*, 8372*; Angew. Chem., Int. Ed*. **2013**, *52*, 8214.

[12] Reviews: a) B. V. S. Reddy, P. N. Nair, A. Antony, N. Srivastava, *Eur. J. Org. Chem*. **2017**, 5484; b) C.-L. Sun, Z.-J. Shi, *Chem. Rev*. **2014**, *114*, 9219. Some selected recent advances in $BF_3{\cdot}OEt_2$ catalyzed or mediated reactions: c) P. Ghosh, P. Saha, S. Bondalapati, K. Indukuri, A. K. Saikia, *J. Org. Chem*. **2014**, *79*, 4119; d) M. J. Deka, K. Indukuri, S. Sultana, M. Borah, A. K. Saikia, *J. Org. Chem*. **2015**, *80*, 4349; e) G. C. Senadi, B. S. Gore, W.-P. Hu, J.-J. Wang, *Org. Lett*. **2016**, 18, 2890; f) W. Mao, C. Zhu, *Chem. Commun*. **2016**, *52*, 5269; g) M.-Y. Chang, Y.-C. Cheng, *Org. Lett*. **2016**, *18*, 1682; h) S. Sultana, S. M. B. Maezono, M. S. Akhtar, J.-J. Shim,Y.-J. Wee, S. H. Kim, Y. R. Lee, *Adv. Synth. Catal.* **2018**, *360*, 751.

10.1002/adsc.201901266

[13] a) A. J. Cresswell, S. G. Davies, P. M. Roberts, J. E. Thomson, *Chem*. *Rev*. **2015**, *115*, 566 and see the ref. cited inside; b) M.-C. P. Yeh, C.-J. Liang, T.-L. Huang, H.-J. Hsu, Y.-S. Tsau, *J*. *Org*. *Chem*. **2013**, *78*, 5521; c) J. Cui, Q. Jia, R.-Z. Feng, S.-S. Liu, T. He, C. Zhang, *Org*. *Lett*. **2014**, *16*, 1442; d) M. F. Wempe, J. R. Grunwell, *Tetrahedron Lett.* **2000**, *41*, 6709.

[14] a) J. Ouyang, J. L. Kennemur, C. D. De, C. Farès, B. List, *J. Am. Chem. Soc*. **2019**, *141*, 3414; b) G. E. Hutson, Y. E.Türkmen, V. H. Rawal, *J. Am. Chem. Soc*. **2013**, *135*, 4988; c) R. William, S.Wang, A. Mallick, X.-W. Liu, *Org. Lett.* **2016**, *18*, 4458; d) V. Z. Shirinian, A. G. Lvov, A. V. Yadykov, L. V.Yaminova, V. V. Kachala, A. I. Markosyan, *Org. Lett.* **2016**, *18*, 6260; e) H. Zhang, B. Cheng, Z. Lu, *Org. Lett.* **2018**, *20*, 4028.

[15] C. Holt, G. Alachouzos, A. J. Frontier, *J. Am. Chem. Soc.* **2019**, *141*, 5461.

[16] B. D. Rowsell, R. J. Gillespie, G. L. Heard, *Inorg. Chem.* **1999**, *38*, 4659.

[17] a) Y. Liu, P. Zhao, B. Zhang, C. Xi, *Org*. *Chem*. *Front*. **2016**, *3*, 1116; b) J. Zhu, C. Zhong, H.-F. Lu, G.-Y. Li, X. Sun, *Synlett*. **2008**, *3*, 458.

[18] K. K. Laali, B. M. Rathman, S. D. Bunge, X. Qi and G. L. Borosky, *J*. *Fluor*. *Chem*. **2016**, *191*, 29.

[19] S. Balalaie, M. Ashouriha, F. Rominger, H. R. Bijanzadeh, *Mol Divers.* **2013**, *17*, 55.

10.1002/adsc.201901266

FULL PAPER

Construction of Halofunctionalized Indenes via a Cascade Prins-Nazarov Cyclization Promoted by Dual Roles of BX_3

Adv. Synth. Catal. **Year**, *Volume*, Page – Page

Sabera Sultana[a] and Yong Rok Lee[a]*