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BF_3•OEt_2 Mediated Tandem Annulation: A Strategy to Construct Functionalized Chromeno-, and Pyrano- Fused Pyridines

Ashitha K. T, Praveen Kumar V, Fathimath Salfeena C. T, Sasidhar B. S*

Chemical Sciences and Technology Division, CSIR-National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram - 695 019, India.

Academy of Scientific and Innovative Research (AcSIR), CSIR-NIIST, Thiruvananthapuram 695 019, India.

**Corresponding author: Sasidhar B. S,*
E-mail: drsasidharbs@niist.res.in

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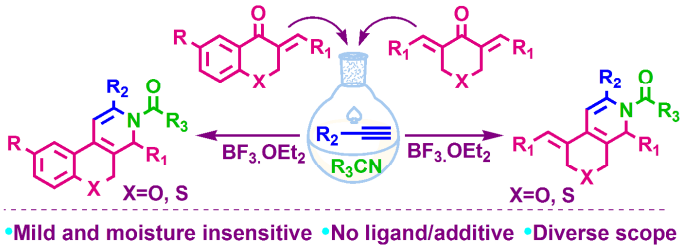


Abstract: A simple and efficient one-pot annulation of arylidenones, alkynes, and nitriles in the presence of $BF_3.OEt_2$ is described. A highly functionalized variety of N-substituted pyridine fused-, chromeno and pyrano derivatives obtained with satisfactory yields under mild reaction conditions. The method was proven to be valid for the synthesis of the diverse library of chromeno [3,4-*c*]pyridines, thiochromeno[3,4-*c*]pyridines, pyrano[3,4-*c*]pyridines, thiopyrano[3,4-*c*]pyridine derivatives from readily accessible substrates. This experimentally simple protocol provides structurally complex, biologically relevant heterocycles in a one-pot operation.

Introduction

Chromone is an essential class of oxygen-containing heterocyclic compounds. Chromones are among the most exciting discoveries in the field of natural products which have successfully led to the development of many approved drugs and clinical trial agents[1] (Figure 1). In fact, these class of compounds is known to have the broad spectrum of medicinal properties, including antitumor,[2] antibacterial,[3] anti-HIV,[4] acetyl-CoA carboxylase (ACC) inhibitor,[5] etc. Many pharmacologically relevant natural products such as hematoxylin, ripariochromene, clausenin and calanolide A, have been synthesised from versatile intermediate chromanone.[6] On the other hand, pyridine as privileged *N*-heterocycle is associated with various natural products and pharmaceuticals.[7] Interestingly, more than a hundred currently marketed drugs contain this core.[8]

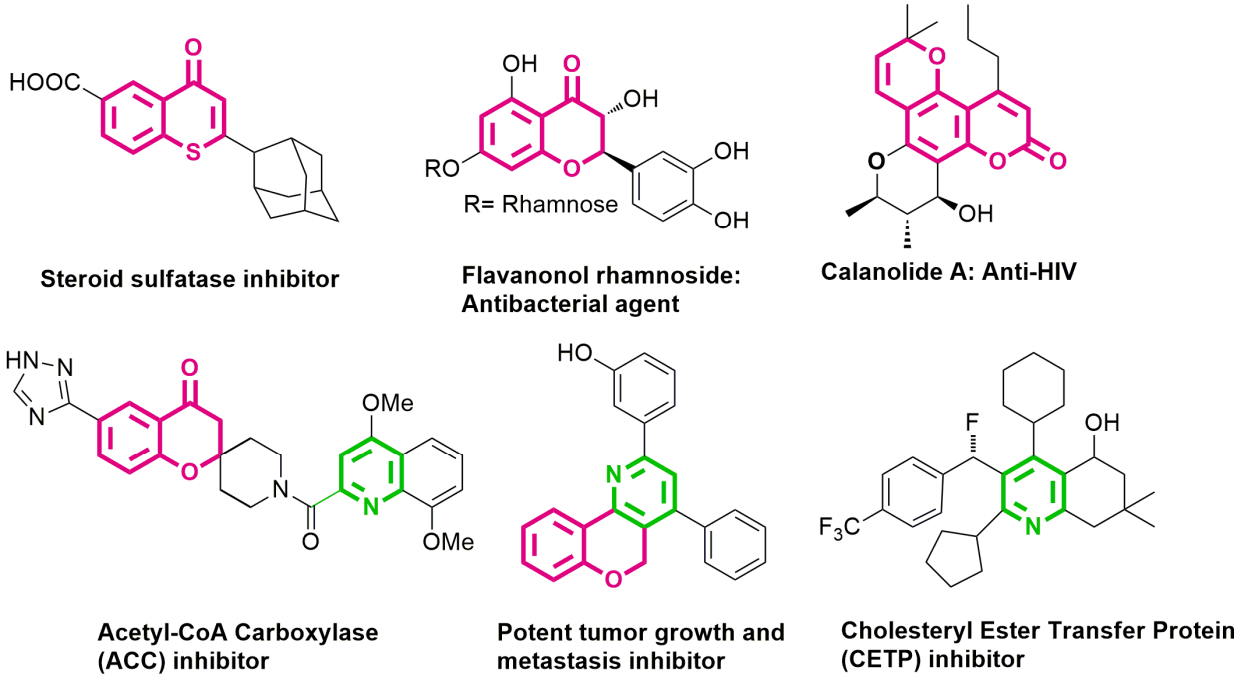


Figure 1. Medicinally relevant chromane, thiochromane and pyridine derivatives

The medicinal properties of these compounds are associated with their bi- and tricyclic molecular hybrids. Consequently, a variety of chimeric structures of chromones[1d,9] and pyridines[8,10] have been prepared and evaluated for therapeutic applications. In 1997 Unangst *et al.* synthesised chromeno[3,4-*c*]pyridin-5-ones by a cyclocondensation of an appropriate phenol with a piperidone ester under strongly acidic conditions.[11] Zhou *et al*. reported Microwave

assisted, cobalt-catalysed intramolecular [2+2+2] cyclization of dialkynylnitriles to pyrano[3,4-*c*][1,6]naphthyridines.[12] Panda and coworkers demonstrated one-pot cyclization for the preparation of cyclic ethers from their diols *via* a tandem oxidation-reduction protocol. The protocol was also generalized for the synthesis of pyrano[3,4-*c*]pyridine derivative.[13] In the total synthesis of Camptothecin and SN-38, an important precursor (*S*)-4-ethyl-4-hydroxy-8-methoxy-1*H*-pyrano[3,4-*c*]pyridin-3(4*H*)-one was achieved through the multi-step process starting from 2-methoxypyridine-3-carboxylic acid.[14] These highlighted methods mainly possess the drawbacks such as unavailability of starting substrates and multi-step synthesis.

The generation of hybrid pharmacophore through the fusion of medicinally active chromenones / pyranones and pyridines will undoubtedly enrich the structural template. Therefore, the development of these enriched structural templates through the multiple bond-forming transformations involving multicomponent reactions (MCRs) in one-pot is the key to generating molecular diversity. The significant applications of MCRs in the drug discovery process,[15] total synthesis,[16] and in the development of various strategies for the construction of new chemical entities is quite evident.[17]

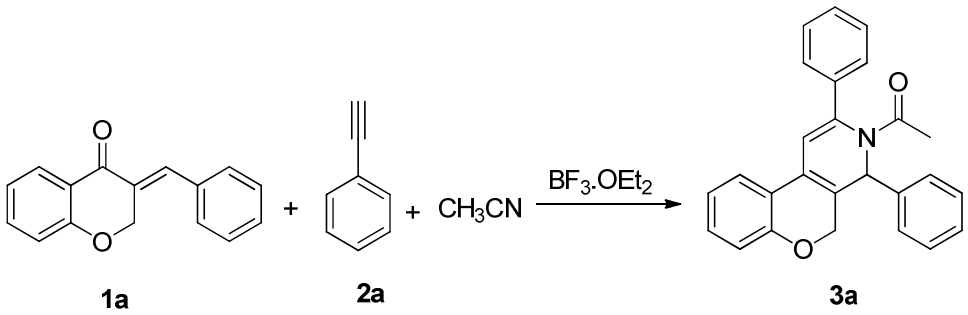
Owing to the aforementioned biological importance of pyridines, related hybrids, and our interest in the design and development[18] of medicinally essential heterocycles, recently we have unraveled a one-pot multicomponent cascade synthesis of pyridine appended heterocycles from the readily accessible arylidenones, alkynes and nitriles.[19] This simple protocol has led us now to report the diverse library of chromeno[3,4-*c*]pyridines, thiochromeno[3,4-*c*]pyridines, pyrano[3,4-*c*]pyridines and thiopyrano[3,4-*c*]pyridines.

Results and Discussion

In sharp contrast to the well-documented approaches to access either chromeno[4,3-*b*]pyridines[10b,20] or chromeno[3,2-*c*]pyridines,[21] we report a one-pot, multicomponent cascade annulation for the construction of chromeno[3,4-*c*]pyridines. To the extension of our recent report,[16] the feasibility of this annulation reaction was first tested using one equivalent of (*E*)-3-benzylidene chroman-4-one (**1a**), phenylacetylene (**2a**) and acetonitrile in the presence of one equivalent of $BF_3.OEt_2$ at 50 ^oC, which presumably afforded 1-(2,4-diphenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl) ethanone (**3a**), in 22% of yield (Table 1, entry 2). The model

reaction was also examined for various Lewis acids like $Sc(OTf)_3$, $Zn(OTf)_2$, $Cu(OTf)_2$, $La(OTf)_3$, etc. However, the reaction did not afford the expected product. Bronsted acids TFA, benzoic acid, and phenylboronic acid etc., failed to furnish the product even in trace amount. Addition of two equivalent of acetonitrile in the presence of other solvents such as toluene, DCE, DCM, afforded the product in meager yields, while THF and DMF did not show any positive result (Table 1, entries 3–7). When we tried to optimize with carbophilic Lewis acids, such as $AuCl_3$, $AuPPh_3$, $AuCl_3H_2O$, $Cu(OAc)_2$ and I_2 as additives, along with the $BF_3.OEt_2$, we could not find any marked improvement in the reaction. Further, the reaction was observed at varying temperature. Low yield of about 12% is obtained for the room temperature reaction. On increasing the temperature from 50 ^oC, the reaction started to produce some byproducts which apparently resulted in poor yields. From the optimization parameters listed in Table 1, an addition of three equivalent of $BF_3.OEt_2$, with three equivalent of an alkyne, without any co-solvent (Table 1, entry 26) at 50 ^oC emerges as the optimized condition, furnishing the highest yield (66%) of the targeted chromeno[3,4-*c*]pyridine.

Table 1. Optimization of the Reaction Conditions[a]

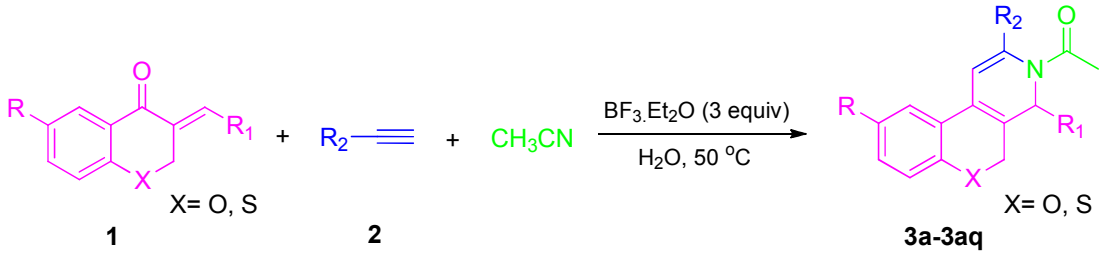


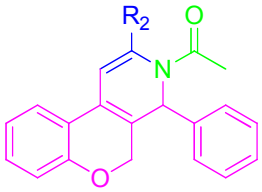
1a **2a** **3a**

Entry	1a	2a	Lewis acid	Solvent	Temp (°C)	Yield (%)[b]
1	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	CH_3CN	rt	12
2	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	CH_3CN	50	22
3	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	Toluene+ CH_3CN (2 equiv)	50	Trace
4	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	DCE+ CH_3CN (2 equiv)	50	Trace
5	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	DCM+ CH_3CN (2 equiv)	50	Trace
6	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	THF + CH_3CN (2 equiv)	50	0
7	1 equiv	1equiv	$BF_3.OEt_2$ (1 equiv)	DMF + CH_3CN (2 equiv)	50	0
8	1 equiv	1 equiv	$AlCl_3$	CH_3CN	50	0
9	1 equiv	1 equiv	$GaBr_3$	CH_3CN	50	0
10	1 equiv	1 equiv	$ZnCl_2$	CH_3CN	50	0
11	1 equiv	1 equiv	I_2	CH_3CN	50	0
12	1 equiv	1 equiv	CF_3COOH	CH_3CN	50	0
13	1 equiv	1 equiv	PTSA	CH_3CN	50	0
14	1 equiv	1 equiv	$PhB(OH)_2$	CH_3CN	50	0
15	1 equiv	1 equiv	$Sc(OTf)_3$	CH_3CN	50	0
16	1 equiv	1 equiv	$Cu(OTf)_2$	CH_3CN	50	0
17	1 equiv	1 equiv	$Zn(OTf)_2$	CH_3CN	50	0
18	1 equiv	1 equiv	$BF_3.OEt_2$ (1 equiv)+ $AuPPh_3$ (20 mol%)	CH_3CN	50	20
19	1 equiv	1 equiv	$BF_3.OEt_2$ + $AuCl_3$	CH_3CN	50	23
20	1 equiv	1 equiv	$BF_3.OEt_2$ + $AuCl_3.H_2O$)	CH_3CN	50	21
21	1 equiv	1 equiv	$BF_3.OEt_2$ + $Cu(OAc)_2$	CH_3CN	50	0
22	1 equiv	1 equiv	$BF_3.OEt_2$ + I_2	CH_3CN	50	0
23	1 equiv	2 equiv	$BF_3.OEt_2$ (1 equiv)	CH_3CN	50	30
24	1 equiv	3 equiv	BF_3. OEt_2 (1 equiv)	CH_3CN	50	42
25	1 equiv	3 equiv	$BF_3.OEt_2$ (2 equiv)	CH_3CN	50	56
26	**1 equiv**	**3 equiv**	**$BF_3.OEt_2$ (3** equiv)	**CH_3CN**	**50**	**66**

[a]Unless otherwise specified, all of the reactions were carried out at 50 °C, **1a** (0.12 mmol), H_2O (0.24 mmol) in 2 mL of CH_3CN. [b]Isolated yield.

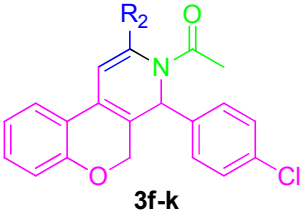
With the optimized reaction condition in hand, all the subsequent reactions of (*E*)-3-arylidene chroman-4-one (1 equiv) and aryl or heteroaryl alkynes (3 equiv) were performed in the presence of $BF_3.OEt_2$ (3 equiv) at 50 ^oC in acetonitrile for 10 - 90 minutes. After completion of -





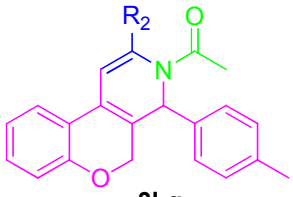
3a-e

3a; R_2= Ph, 66%
3b; R_2= 4-CH_3-Ph, 56%
3c; R_2= 4-Br-Ph, 52%
3d; R_2= 4-F-Ph, 42%
3e; R_2= 4-propyl-Ph, 43%



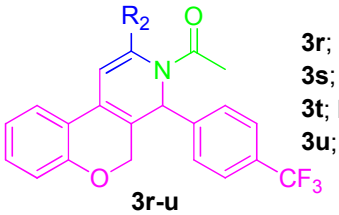
3f-k

3f; R_2= Ph, 39%
3g; R_2= 4-CH_3-Ph, 63%
3h; R_2= 4-Br-Ph, 49%
3i; R_2= 4-F-Ph, 48%
3j; R_2= 4-propyl-Ph, 55%
3k; R_2= 3-thiophen, 60%



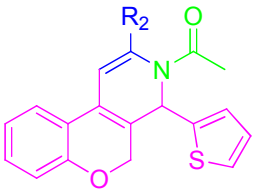
3l-q

3l; R_2= Ph, 74%
3m; R_2= 4-CH_3-Ph, 77%
3n; R_2= 4-Br-Ph, 61%
3o; R_2= 4-F-Ph, 62%
3p; R_2= 4-propyl-Ph, 74%
3q; R_2= 3-thiophen, 77%



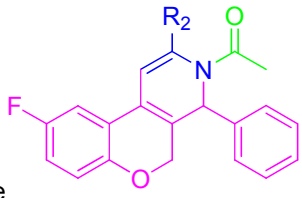
3r-u

3r; R_2= Ph, 36%
3s; R_2= 4-CH_3-Ph, 54%
3t; R_2= 4-F-Ph, 32%
3u; R_2= 4-propyl-Ph, 47%



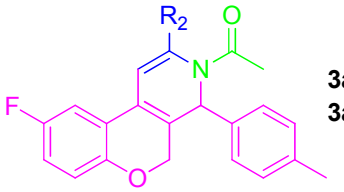
3v-aa

3v; R_2= Ph, 50%
3w; R_2= 4-CH_3-Ph, 74%
3x; R_2= 4-Br-Ph, 38%
3y; R_2= 4-F-Ph, 24%
3z; R_2= 4-propyl-Ph, 47%
3aa; R_2= 3-thiophen, trace



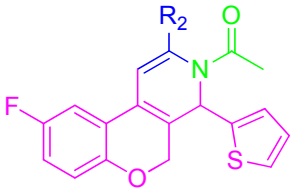
3ab-ag

3ab; R_2= Ph, 63%
3ac; R_2= 4-CH_3-Ph, 67%
3ad; R_2= 4-Br-Ph, 39%
3ae; R_2= 4-F-Ph, 51%
3af; R_2= 4-propyl-Ph, 50%
3ag; R_2= 3-thiophen, 33%



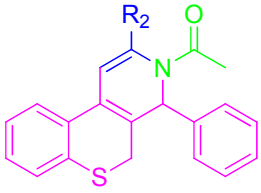
3ah-ai

3ah; R_2= Ph, trace
3ai; R_2= 4-Br-Ph, 36%



3aj-ak

3aj; R_2= Ph, 64%
3ak; R_2= 4-CH_3-Ph, 41%



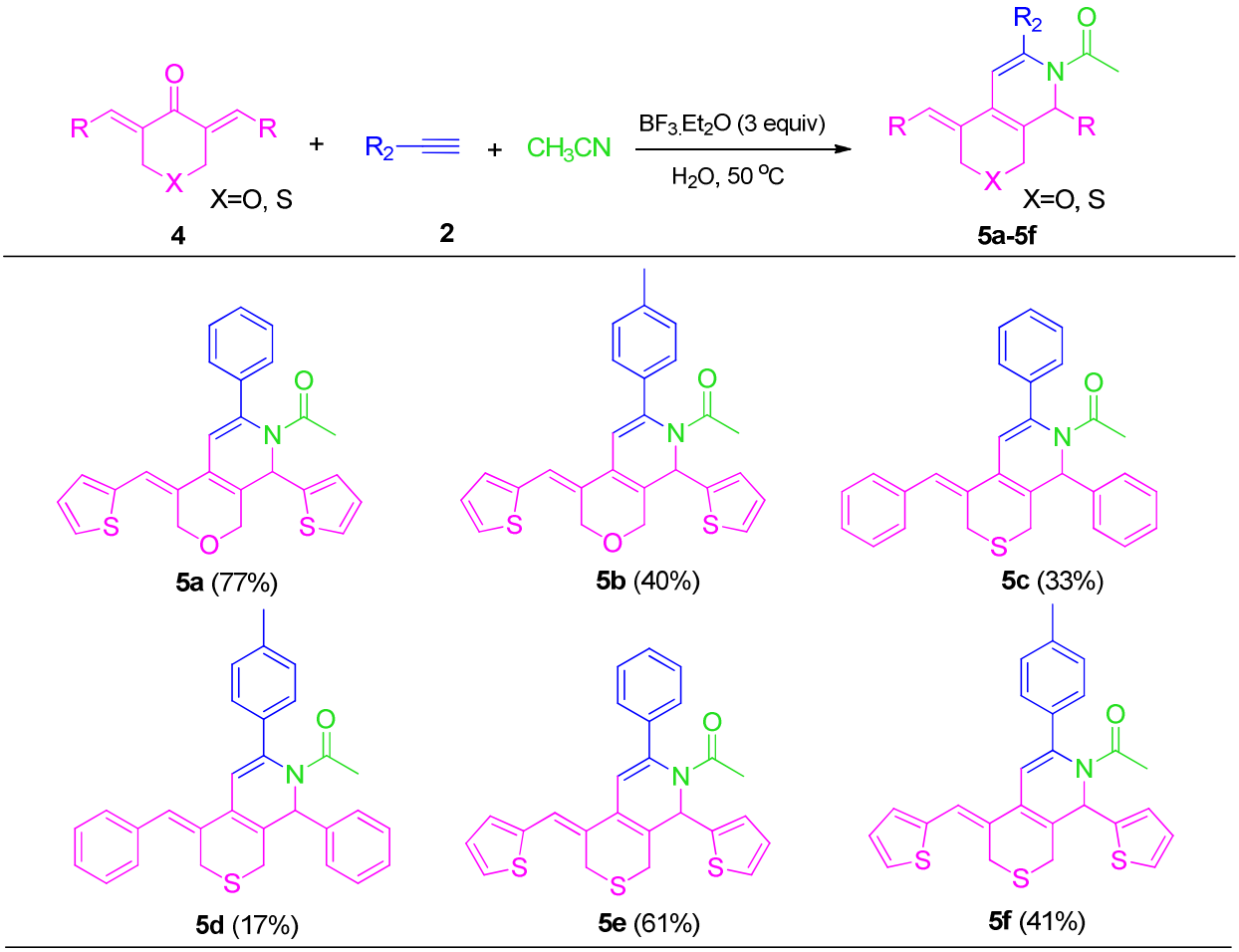
3al-aq

3al; R_2= Ph, 46%
3am; R_2= 4-CH_3-Ph, 26%
3an; R_2= 4-Br-Ph, 31%
3ao; R_2= 4-F-Ph, 40%
3ap; R_2= 4-propyl-Ph, 23%
3aq; R_2= 3-thiophen, 39%

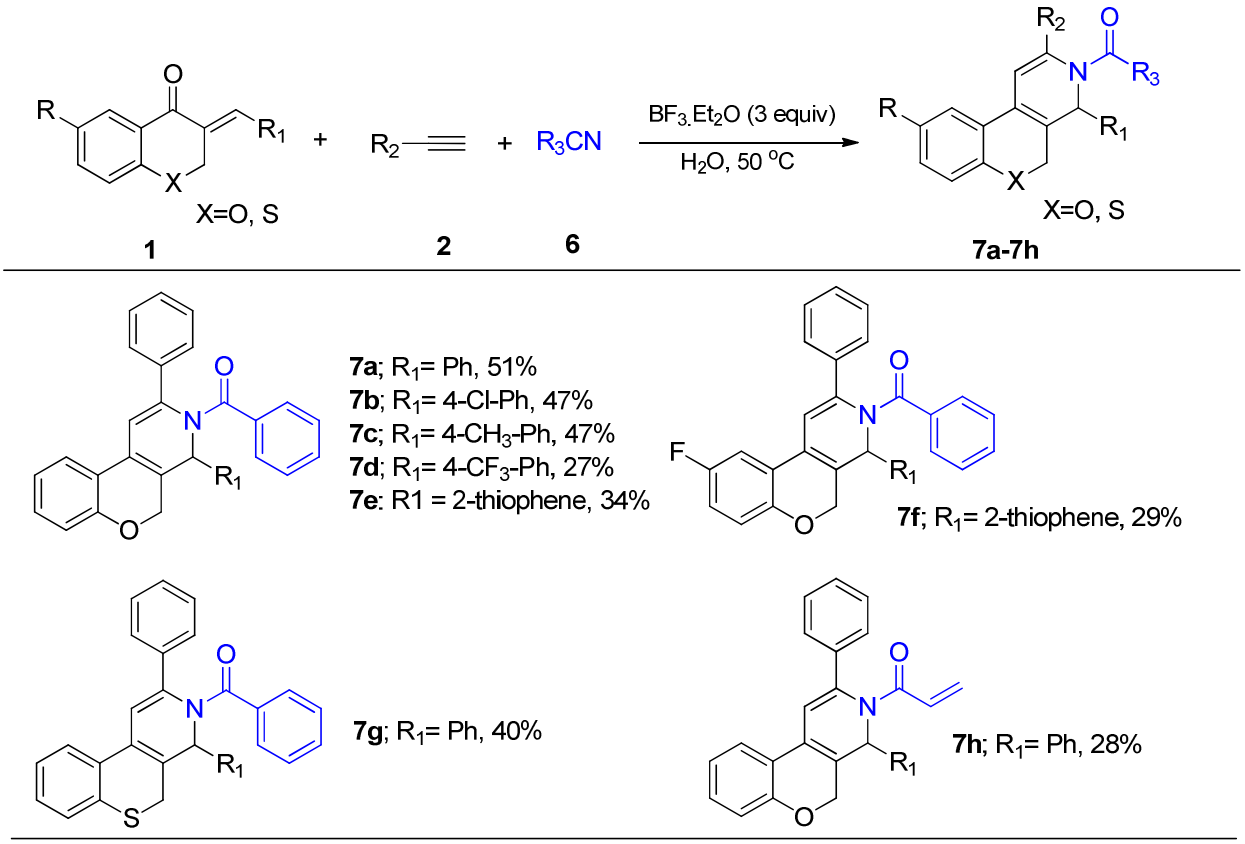
Scheme 1. Scope of the reaction for *N*-acetylated, chromeno and thiochromeno [3,4-*c*]pyridines

- the reaction as evident from TLC, the product extracted with ethyl acetate and purified by column chromatography to obtain pure chromeno[3,4-*c*]pyridine derivatives (**3**). The generality of this three-component annulation was well explored for substituted (*E*)-3-arylidenechroman-4-one, aromatic acetylenes, bearing a series of electron withdrawing and electron donating substituents and heteroaryl ring thiophene. 6-Fluoro arylidene chromanones were also generalized with the variety of arylidene and alkynes in the presence of acetonitrile. These different, electronically substituted varied reagents reacted efficiently under the optimized condition affording the corresponding chromeno[3,4-*c*] pyridines in acceptable yields (Scheme 1). We turned our attention to assessing the scope of this annulation reaction with arylidene thiochromanone, alkynes, bearing a series of electron withdrawing and electron donating substituents. In all the cases methodology worked well to synthesize the targeted thiochromeno[3,4-*c*]pyridines (**3al-aq**) in moderate to good yields (Scheme 1). From our observation, we found that the yields of the thiochromeno[3,4-*c*]pyridines are lower than that of the chromeno[3,4-*c*]pyridines. It may be attributed to the basicity of heteroatom sulphur as compared to that of oxygen.

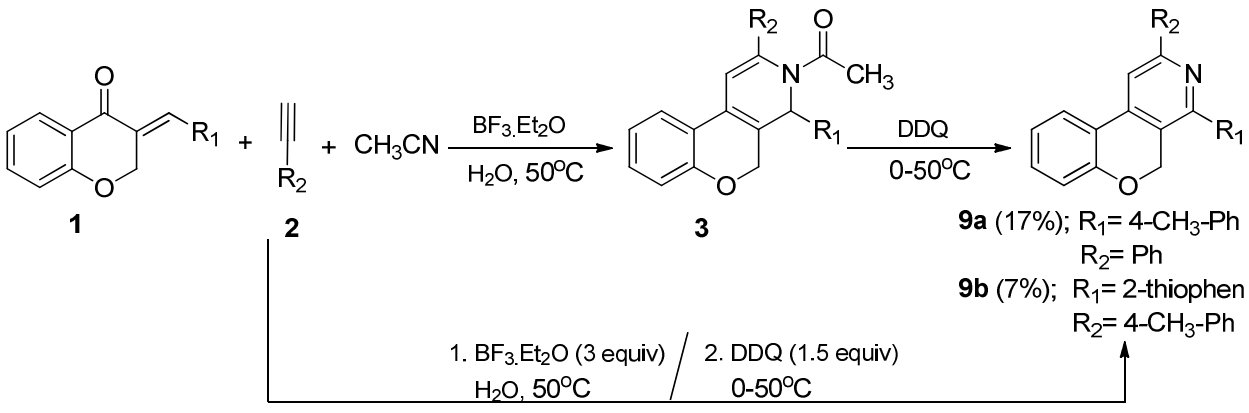
The successful annulation of chromeno[3,4-*c*]pyridines and thiochromeno[3,4-*c*]pyridines led us to examine the reactivity of (3*E*,5*E*)-3,5-diarylidenedihydro-2*H*-pyran-4(3*H*)-one and (3*Z*,5*Z*)-3,5-diarylidenedihydro-2*H*-thiopyran-4(3*H*)-one with various substituted alkynes and acetonitrile under the same optimized condition. Pyranone and thiopyranone diarylidenes (**4**) derived from phenyl and thiophenes were utilized for the three component cascade annulation. To our delight, we were fortunate to get the new molecular templates of pyrano[3,4-*c*]pyridines and thiopyrano[3,4-*c*]pyridines (**5**) in acceptable yields (Scheme 2). Delighted with the success of broad diversity of arylidenones and alkynes, we further explored the compatibility of other nitrile sources such as, benzonitrile and acrylonitrile. As targeted; we successfully obtained *N*-substituted chromeno and thiochromeno-fused pyridines (**7**) under mild and straightforward reaction conditions in acceptable yields (Scheme 3). Finally, under the DDQ oxidation condition product **3** (3l & 3w) were successfully transformed in to the corresponding 5*H*-chromeno[3,4-*c*]pyridines of biological relevance (Scheme 4).



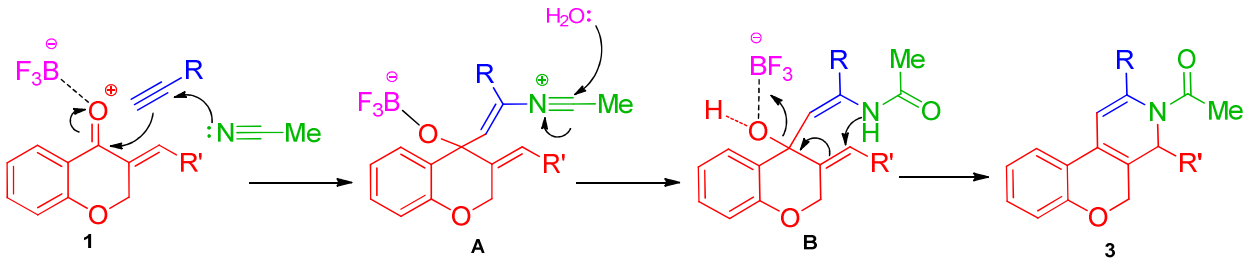
Scheme 2. Generality of pyrano-, thiopyrano-, [3,4-*c*]pyridine synthesis.



Scheme 3. Scope of nitriles for [3,4-*c*]pyridine synthesis.



Scheme 4. One-pot synthesis of 5*H*-chromeno[3,4-*c*]pyridines.



Scheme 5. Plausible mechanism of chromeno[3,4-*c*]pyridine formation.

Based on the aforementioned experimental results, a plausible mechanistic pathway is outlined in scheme 5**.** Being oxophilic in nature $BF_3.OEt_2$ coordinates to the carbonyl oxygen of arylidene ketone **1**, favouring the carbonyl group to undergo 1,2 addition by phenylacetylene. This is followed by the attack of acetonitrile to phenyl acetylene leading to the formation of intermediate **A**. Hydrolysis of nitrile group of intermediate **A** under acidic conditions leads to the creation of intermediate **B** which on subsequent Intramolecular cyclisation of amide nitrogen affords the product **3**.

Conclusion

In conclusion, a simple and efficient $BF_3.OEt_2$ mediated cascade annulation of arylidenones, alkynes and nitriles have been developed. This reaction affords a highly generalized and straightforward way to construct *N*-substituted chromeno-, thiochromeno-, pyrano- and thiopyrano-, [3,4-*c*]pyridines under mild conditions and tolerates a wide range of functional groups. In addition, a one-pot synthesis of 5*H*-chromeno[3,4-*c*]pyridines was successfully achieved. Notably, the reaction is process friendly, with easily accessible substrates and without any inert conditions. A plausible mechanism of the reaction has proposed. Our protocol will aid in the generation of a diverse library of fused pyridine hybrids with potential biological significance. Further investigation for the construction of other heterocyclic appended fused pyridines via this annulation reaction is in progress at our laboratory.

Experimental Section

General experimental methods: All the reactions are performed with commercially available best grade chemicals without further purification. All the solvents used are reagent grade and commercially available. Column chromatography was performed using 100 – 200 mesh silica gel and mixtures of hexane – ethyl acetate were used for elution of the products. Proton nuclear magnetic resonance spectra (^{1}H NMR) were recorded on a Bruker AMX 500 spectrometer ($CDCl_3$ as solvent). Chemical shifts for ^{1}H NMR spectra are reported as δ in units of parts per million (ppm) downfield from $SiMe_4$ (δ 0.0) and relative to the signal of chloroform-d (δ 7.25, singlet). Multiplicities were given as: s (singlet); d (doublet); t (triplet); q (quartet); dd (doublet of doublet); dt (doublet of triplet), m (multiplet). Coupling constants are reported as *J* value in Hz. Carbon nuclear magnetic resonance spectra (^{13}C NMR) are reported as δ in units of parts per million (ppm) downfield from $SiMe_4$ (δ 0.0) and relative to the signal of chloroform-d (δ 77.03, triplet). HRMS analysis was recorded on a Thermo Scientific Exactive-LCMS instrument by electron spray ionization method with ions given in *m/z* using Orbitrap analyzer. IR spectra were recorded on Bruker FT-IR spectrometer.

General procedure for the synthesis of arylidene chroman-4-ones, thiochroman-4-ones (1)[22]

To a solution of chroman-4-one/thiochroma-4-one (4.0 mmol) in ethanol added corresponding aryl or hetero aryl aldehyde (4.40 mmol) at 0 ^{o}C. An aqueous solution of NaOH (10%, 10 ml) was added drop wise to this reaction mixture. The solid precipitate formed was collected by filtration and washed with water and hexane. It was dried and used for further reaction.

General procedure for the synthesis of (3*E*, 5*E*)-3,5-diarylidenedihydro-2*H*-pyran-4(3*H*)-one / (3*Z*, 5*Z*)-3,5-diarylidenedihydro-2*H*-thiopyran-4(3*H*)-one (4)[22]

To a solution of dihydro-2*H*-pyran-4(3*H*)-one / dihydro-2*H*-thiopyran-4(3*H*)-one (2.00 mmol) in ethanol added corresponding aryl or hetero aryl aldehyde (2.20 mmol) at 0 ^{o}C. An aqueous solution of NaOH (10%, 10 ml) was added drop wise to this reaction mixture. The solid precipitate formed was collected by filtration and washed with water and hexane. It was dried and used for further reaction

General procedure for $BF_3.OEt_2$ mediated one-pot synthesis of *N*-acetylated chromeno[3,4-*c*]pyridines / thiochromeno[3,4-*c*]pyridines (3)

To a mixture of 1 equiv of substituted arylidene chroman-4-one / thiochroman-4-one (0.12 mmol) and 3 equiv of aryl or hetero aryl alkyne (0.36 mmol) in acetonitrile (2 ml) with 2 equiv of water at 50 ^oC added 3 equiv of $BF_3.OEt_2$ (0.36 mmol). The reaction mixture was then allowed to stir for 10 - 90 minutes by monitoring the TLC. After the completion of reaction the reaction mixture was extracted with ethyl acetate (3 X 10 ml), evaporated in *vacuo* and purified by column chromatography using 100–200 mesh silica gel with ethyl acetate / hexane as the eluent to afford the corresponding *N*-acetylated fused pyridines as the product.

1-(2,4-diphenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3a)

Yield: 30 mg, 66% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1661, 1601, 1036**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.51 (d, *J* = 7.0 Hz, 2H), 7.40 (d, *J* = 6.5 Hz, 1H), 7.35 – 7.29 (m, 3H), 7.28 – 7.26 (m, 4H), 7.22 (td, *J* = 8.0, 1.5 Hz, 1H), 7.13 (s, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.52 (s, 1H), 6.44 (s, 1H), 4.90 (d, *J* = 15.5 Hz, 1H), 4.77 (d, *J* = 15.0 Hz, 1H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$)** δ 172.0, 153.9, 138.5, 138.3, 137.2, 129.5, 129.0, 128.8, 128.6, 128.5, 128.1, 125.8, 124.7, 123.0, 121.7, 120.9, 116.5, 112.0, 65.8, 53.5, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{21}NO_2Na$ 402.1470; Found 402.1461.

1-(4-phenyl-2-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3b)

Yield: 26 mg, 56% yield, as colorless foam**;** R_f = 0.21 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3061, 1666, 1604, 1116**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.52 – 7.49 (m, 2H), 7.39 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.34 – 7.27 (m, 3H), 7.21 (td, *J* = 8.0, 1.5 Hz, 1H), 7.07 (d, *J* = 8.0 Hz, 2H), 7.02 (td, *J* = 7.5, 1.0 Hz, 3H), 6.90 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.50 (s, 1H), 6.40 (s, 1H), 4.89 (d, *J* = 15.5 Hz, 1H), 4.76 (d, *J* = 15.0 Hz, 1H), 2.30 (s, 3H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 153.9, 138.8, 138.3, 137.2, 135.7, 133.2, 129.7, 129.4, 128.8, 128.6, 128.4, 128.3, 128.1, 125.7, 125.5, 124.7, 123.1, 121.7, 121.0, 116.5, 111.3, 65.8, 53.5, 24.8, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{23}NO_2Na$ 416.1626; Found 416.1620.

1-(2-(4-bromophenyl)-4-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3c)

Yeild: 29 mg, 52% yield, as colorless foam**;** R_f = 0.19 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1669, 1586, 1072, 1040**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.50 – 7.46 (m, 2H), 7.40 (d, *J* = 8.5 Hz, 2H), 7.37 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.34 – 7.29 (m, 3H), 7.22 (td, *J* = 8.0, 1.5 Hz, 1H), 7.02 (td, *J* = 7.5, 1.0 Hz, 1H), 6.99 (d, *J* = 7.0 Hz, 2H), 6.91 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.50 (s, 1H), 6.44 (s, 1H), 4.88 (d, *J* = 15.5 Hz, 1H), 4.75 (d, *J* = 15.5 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.7, 153.8, 137.5, 137.2, 137.0, 132.2, 129.6, 128.9, 128.6, 128.0, 127.2, 126.4, 124.7, 123.0, 122.7, 121.7, 120.7, 116.6, 112.6, 65.7, 53.5, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}BrNO_2Na$ 480.0575; Found 480.0580.

1-(2-(4-fluorophenyl)-4-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3d)

Yeild: 20 mg, 42% yield, as colorless foam**;** R_f = 0.16 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3065, 1667, 1599,1098**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.50 – 7.49 (m, 2H), 7.38 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.35 – 7.29 (m, 3H), 7.21 (td, *J* = 8.0, 1.5 Hz, 1H), 7.09 (s, 2H), 7.02 (td, *J* = 7.5, 1 Hz, 1H), 6.96 (t, *J* = 9.0 Hz, 2H), 6.91 (dd, *J* = 8.0, 0.5 Hz, 1H), 6.51 (s, 1H), 6.39 (s, 1H), 4.88 (d, *J* = 15.5 Hz, 1H), 4.76 (d, *J* = 15.0 Hz, 1H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.8, 153.8, 137.2, 137.1, 134.7, 134.7, 133.7, 131.6, 129.5, 128.9, 128.6, 128.1, 127.5, 127.4, 125.8, 124.7, 123.0, 121.7, 120.8, 116.6, 116.2, 116.0, 112.0, 65.7, 53.5, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}FNO_2Na$ 420.1376; Found 420.1376.

1-(4-phenyl-2-(4-propylphenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3e)

Yeild:22 mg, 43% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1666, 1606, 1040**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.51 (d, *J* = 7.0 Hz, 2H), 7.39 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.34 – 7.28 (m, 3H), 7.21 (td, *J* = 8.0, 1.5 Hz, 1H), 7.08 – 7.00 (m, 5H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.50 (s, 1H), 6.40 (s, 1H), 4.89 (d, *J* = 15.5 Hz, 1H), 4.76 (d, *J* = 15.5 Hz, 1H), 2.54 – 2.51 (m, 2H), 1.71 (s, 3H), 1.60 – 1.56 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.2, 153.9, 143.5, 138.4, 137.3, 135.9, 129.4, 129.1, 128.8, 128.4, 128.1, 125.7, 125.4, 124.7, 123.1, 121.7, 121.0, 116.5, 111.2, 65.8, 53.5, 37.7, 24.7, 24.4, 13.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{27}NO_2Na$ 444.1939; Found 444.1943.

1-(4-(4-chlorophenyl)-2-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3f)

Yield: 19 mg, 39% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1666, 1593, 1091**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.45 (d, *J* = 8.5 Hz, 2H), 7.40 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.31 – 7.28 (m, 5H), 7.22 (td, *J* = 8.0, 1.5 Hz, 1H), 7.12 (s, 2H), 7.03 (td, *J* = 7.5, 1 Hz, 1H), 6.92 (dd, *J* = 8.5, 1.0 Hz, 1H), 6.47 (s, 1H), 6.44 (s, 1H), 4.88 (d, *J* = 15.5 Hz, 1H), 4.71 (d, *J* = 15.0 Hz, 1H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$)** δ 172.1, 153.8, 138.3, 138.3, 135.8, 134.4, 129.6, 129.1, 129.1, 128.8, 125.7, 125.1, 125.0, 123.1, 121.8, 120.7, 116.6, 111.8, 65.6, 52.8, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}ClNO_2Na$ 436.1080; Found: 436.1089.

1-(4-(4-chlorophenyl)-2-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3g)

Yield: 32 mg, 63% yield, as colorless foam**;** R_f = 0.28 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3035, 1667, 1588, 1091**; ^{1}H NMR (500 MHz, CDCl$_3$)** δ 7.44 (d, *J* = 8.5Hz, 2H), 7.39 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.22 (td, *J* = 8.0, 1.5 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 2H), 7.02 (td, *J* = 7.5, 1.0 Hz, 3H), 6.91 (dd, *J* = 8.5, 1.0 Hz, 1H), 6.46 (s, 1H), 6.40 (s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.71 (d, *J* = 15.0 Hz, 1H), 2.31 (s, 3H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$)** δ 172.2, 153.9, 139.0, 138.3, 135.8, 135.5, 134.3, 129.8, 129.6, 129.6, 129.0, 125.6, 125.0, 124.8, 123.1, 121.8, 120.8, 116.6, 111.2, 65.6, 52.8, 24.7, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{22}ClNO_2Na$ 450.1237; Found 450.1233.

1-(2-(4-bromophenyl)-4-(4-chlorophenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3h)

Yeild: 29 mg, 49% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2928, 1666, 1588, 1269, 1091**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.43 (dd, *J* = 8.5, 2.0 Hz, 4H), 7.37 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.30 (d, *J* = 8.5 Hz, 2H), 7.23 (td, *J* = 8.0, 1.5 Hz, 1H), 7.03 (td, *J* = 7.5, 1.0 Hz, 1H), 6.99 (d,*J* = 7.0 Hz, 2H), 6.92 (d, *J* = 8.0 Hz, 1H), 6.46 (s, 1H), 6.44 (s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.70 (d, *J* = 15.0 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 171.9, 153.8, 137.2, 137.1, 135.6, 134.5, 133.6, 132.3, 131.6, 129.8, 129.5, 129.2, 127.1, 125.6, 124.9, 123.1, 122.9, 121.8, 120.6, 116.6, 112.4, 65.5, 52.8, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{19}BrClNO_2Na$ 514.0185; Found 514.0177.

1-(4-(4-chlorophenyl)-2-(4-fluorophenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3i)

Yield: 25 mg, 48% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3068, 1669, 1600, 1092**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.44 (d, *J* = 8.5 Hz, 2H), 7.38 (d, *J* = 7.5 Hz, 1H), 7.31 (d, *J* = 8.5 Hz, 2H), 7.23 (td, *J* = 8.0, 1.5 Hz, 1H), 7.09 (s, 2H), 7.04 – 6.97 (m, 3H), 6.92 (d, *J* = 8.0 Hz, 1H), 6.46 (s, 1H), 6.39 (s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.71 (d, *J* = 15.0 Hz, 1H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 171.9, 163.9, 161.9, 153.8, 137.1, 135.7, 134.5, 129.7, 129.5, 129.1, 127.5, 127.4, 124.9, 123.1, 121.8, 120.6, 116.6, 116.3, 116.1, 111.8, 65.6, 52.9, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{19}ClFNO_2Na$ 454.0986; Found 454.0995.

1-(4-(4-chlorophenyl)-2-(4-propylphenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3j)

Yield: 30 mg, 55% yield, as colorless foam**;** R_f = 0.28 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1668, 1588, 1091**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.39 (d, *J* = 7.5 Hz, 1H), 7.26 (d, *J* = 5.5 Hz, 2H), 7.21 (t, *J* = 8.0 Hz, 1H), 7.12 (s, 5H), 7.01 (t, *J* = 7.5 Hz, 1H), 6.93 – 6.89 (m, 2H), 6.65 (s, 1H), 6.41 (s, 1H), 4.89 (d, *J* = 15.5 Hz, 1H), 4.84 (d, *J* = 15.5 Hz, 1H), 2.57 – 2.54 (m, 2H), 1.70 (s, 3H), 1.63 – 1.58 (m, 2H), 0.92 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 171.7, 153.8, 143.6, 140.4, 138.2, 135.9, 129.5, 129.1, 126.8, 126.8, 126.5, 125.9, 125.2, 124.2, 123.2, 121.7, 120.8, 116.5, 110.7, 65.6, 49.7, 37.7, 24.8, 24.4, 13.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{26}ClNO_2Na$ 478.1550; Found 478.1553.

1-(4-(4-chlorophenyl)-2-(thiophen-3-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3k)

Yield: 30 mg, 60% yield, as colorless foam**;** R_f = 0.21 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3106, 1666, 1596, 1090**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.43 (d, *J* = 8.5 Hz, 2H), 7.36 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.29 – 7.27 (m, 3H), 7.22 (td, *J* = 8.0, 1.5 Hz, 1H), 7.03 – 7.00 (m, 2H), 6.92 – 6.90 (m, 2H), 6.42 (s, 2H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.72 (d, *J* = 15.0 Hz, 1H), 1.81 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 172.2, 153.8, 140.1, 135.9, 134.3, 133.6, 130.9, 129.6, 129.5, 129.4, 129.0, 127.2, 125.3, 125.0, 125.0, 123.1, 122.0, 121.8, 120.7, 65.7, 52.7,

24.1**;HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{18}ClNO_2SNa$ 442.0644; Found 442.0636.

1-(2-phenyl-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3l)

Yield: 35 mg, 74% yield, as colorless foam**;** R_f = 0.26 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3060, 1666, 1596, 1090**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.39 (d, *J* = 8.0 Hz, 3H), 7.27 – 7.25 (m, 3H), 7.21 (td, *J* = 8.0, 1.5 Hz, 1H), 7.13 (d, *J* = 8.0 Hz, 4H), 7.02 (td, *J* = 7.5, 1.0 Hz, 1H), 6.91 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.48 (s, 1H), 6.43 (s, 1H), 4.88 (d, *J* = 15.5 Hz, 1H), 4.75 (d, *J* = 15.5 Hz, 1H), 2.30 (s, 3H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 172.0, 153.8, 138.6, 138.3, 138.2, 134.2, 129.5, 129.4, 129.0, 128.6, 128.1, 126.1, 125.8, 124.5, 123.0, 121.7, 121.0, 116.5, 111.9, 65.8, 53.3, 24.7, 21.2.**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{23}NO_2Na$ 416.1626; Found 416.1637.

1-(2,4-di-*p*-tolyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3m)

Yield: 38 mg, 77% yield, as colorless foam**;** R_f = 0.28 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3031, 1666, 1606, 1041**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.39 – 7.37 (m, 3H), 7.20 (td, *J* = 7.5, 1.5 Hz, 1H), 7.12 (d, *J* = 7.5 Hz, 2H), 7.08 (d, *J* = 8.0 Hz, 2H), 7.04 – 6.99 (m, 3H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.46 (s, 1H), 6.39 (s, 1H), 4.88 (d, *J* = 15.0 Hz, 1H), 4.75 (d, *J* = 15.0 Hz, 1H), 2.30 (s, 6H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 172.1, 153.8, 138.7, 138.2, 138.1, 135.8, 134.1, 129.9, 129.7, 129.5, 129.4, 128.0, 125.7, 124.5, 123.0, 121.7, 121.0, 116.5, 111.2, 65.8, 53.2, 24.8, 21.2**;HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$Calcdfor $C_{28}H_{25}NO_2Na$ 430.1783; Found 430.1761.

1-(2-(4-bromophenyl)-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3n)

Yield: 35 mg, 61% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1666, 1587, 1072**; ^{1}H NMR (500 MHz, CDCl$_3$):** δ 7.40 (d, *J* = 8.5 Hz, 2H), 7.37 – 7.34 (m, 3H), 7.21 (td, *J* = 8.0, 1.5 Hz, 1H), 7.12 (d, *J* = 8.0 Hz, 2H), 7.02 (td, *J* = 7.5, 1.0 Hz, 3H), 6.91 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.46 (s, 1H), 6.43 (s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.74 (d, *J* = 15.5 Hz, 1H), 2.31 (s, 3H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, CDCl$_3$):** δ 171.7, 153.8, 138.4, 137.5, 137.1, 133.9, 132.2, 129.6, 129.5, 128.0, 127.2, 126.7, 124.5, 123.0, 122.6, 121.7,

120.7, 116.6, 112.5, 65.8, 53.3, 24.8, 21.2**: HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{22}BrNO_2Na$ 494.0732; Found 494.0721.

1-(2-(4-fluorophenyl)-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3o)

Yield: 31 mg, 62% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**;IR (neat, cm^{-1}):** 3063, 1667, 1600, 1042**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.37 (d, *J* = 7.5 Hz, 3H), 7.21 (td, *J* = 8.0, 2.0 Hz, 1H), 7.13 (d, *J* = 8.0 Hz, 4H), 7.01 (td, *J* = 7.5, 1.0 Hz, 1H), 6.97 (t, *J* = 9.0 Hz, 2H), 6. 91 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.46 (s, 1H), 6.38 (s, 1H), 4.87 (d, *J* = 15.5 Hz, 1H), 4.75 (d, *J* = 15.5 Hz, 1H), 2.31 (s, 3H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.8, 163.8, 161.8, 153.8, 138.3, 137.2, 134.8, 134.1, 129.6, 129.5, 128.0, 127.5, 127.5, 126.1, 124.5, 123.0, 121.7, 120.8, 116.5, 116.2, 116.0, 111.9, 65.8, 53.3, 24.7, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{22}FNO_2Na$ 434.1532; Found 434.1530.

1-(2-(4-propylphenyl)-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3p)

Yield: 39 mg, 74% yield, as colorless foam**;** R_f = 0.30 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2958, 1666, 1588, 1228**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.39 (d, *J* = 8.0 Hz, 3H), 7.20 (t, *J* = 8.0 Hz, 1H), 7.12 (d, *J* = 8.0 Hz, 2H), 7.08 – 7.07 (m, 4H), 7.01 (t, *J* = 7.5 Hz, 1H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.46 (s, 1H), 6.40 (s, 1H), 4.88 (d, *J* = 15.0 Hz, 1H), 4.75 (d, *J* = 15.5 Hz, 1H), 2.55 – 2.52 (m, 2H), 2.30 (s, 3H), 1.70 (s, 3H), 1.61 – 1.56 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H)**;^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 153.9, 143.5, 138.4, 138.1, 136.0, 134.3, 129.5, 129.3, 129.0, 128.0, 125.7, 124.5, 123.0, 121.6, 121.0, 116.5, 111.1, 65.9, 53.3, 37.7, 24.7, 24.3, 21.2, 13.8**;HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{30}H_{29}NO_2Na$ 458.2096; Found 458.2086.

1-(2-(thiophen-3-yl)-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3q)

Yield: 37 mg, 77% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3103, 1663, 1587, 1041**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.37– 7.34 (m, 3H), 7.25 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.20 (td, *J* = 8.0, 1.5 Hz, 1H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.02 – 6.99 (m,

2H), 6.94 (dd, *J* = 5.0, 1.0 Hz, 1H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.42 (d, *J* = 4.5 Hz, 2H), 4.87 (d, *J* = 15.0 Hz, 1H), 4.76 (d, *J* = 15.5 Hz, 1H), 2.29 (s, 3H), 1.80 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 153.8, 140.4, 138.1, 134.3, 133.6, 129.5, 129.4, 127.8, 127.0, 126.1, 125.5, 124.5, 123.0, 122.0, 121.7, 120.9, 116.5, 110.7, 65.9, 53.1, 24.2, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{25}H_{21}NO_2SNa$ 422.1191; Found 422.1196.

1-(2-phenyl-4-(4-(trifluoromethyl)phenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3r)

Yield: 19 mg, 36% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3064, 1665, 1609, 1067**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.65 (d, *J* = 8.0 Hz, 2H), 7.60 (d, *J* = 8.5 Hz, 2H), 7.41 (dd, *J* = 7.5, 1.0 Hz, 1H), 7.31 – 7.29 (m, 3H), 7.23 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.13 (s, 2H), 7.04 (t , *J* = 7.5 Hz, 1H), 6.93 (d, *J* = 8.0 Hz, 1H), 6.55 (s, 1H), 6.45 (s, 1H), 4.90 (d, *J* = 15.5 Hz, 1H), 4.72 (d, *J* = 15.0 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.2, 153.9, 141.4, 138.4, 138.1, 129.8, 129.1, 128.9, 128.6, 125.9, 125.8, 125.7, 125.3, 124.5, 123.2, 121.9, 120.7, 116.6, 111.8, 65.6, 53.0, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{20}F_3NO_2Na$ 470.1344; Found 470.1335.

1-(2-(*p*-tolyl)-4-(4-(trifluoromethyl)phenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3s)

Yield: 30 mg, 54% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3066, 1663, 1166, 1067**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.64 (d, *J* = 8.5 Hz, 2H), 7.59 (d, *J* = 8.5 Hz, 2H), 7.41 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.23 (td, *J* = 8.0, 1.5 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 2H), 7.05 – 7.02 (m, 3H), 6.92 (d, *J* = 8.0 Hz, 1H), 6.54 (s, 1H), 6.42 (s, 1H), 4.89 (d, *J* = 15.5 Hz, 1H), 4.72 (d, *J* = 15.0 Hz, 1H), 2.31 (s, 3H), 1.73 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.3, 153.9, 141.4, 139.1, 138.4, 135.3, 129.8, 129.7, 128.6, 125.8, 125.8, 125.6, 125.3, 124.2, 123.2, 121.8, 120.7, 116.6, 111.0, 65.6, 53.0, 24.7, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{28}H_{22}F_3NO_2Na$ 484.1500; Found 484.1487.

1-(2-(4-fluorophenyl)-4-(4-(trifluoromethyl)phenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3t)

Yield: 18 mg, 32% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3073, 1666, 1601, 1067**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.62 (q, *J* = 8.5 Hz, 4H), 7.39 (d, *J* = 7.5 Hz, 1H), 7.24 (d, *J* = 7.5 Hz, 1H), 7.10 (s, 2H), 7.05 (d, *J* = 7.5 Hz, 1H), 7.02 – 6.98 (m, 2H), 6.93 (d, *J* = 8.0 Hz, 1H), 6.54 (s, 1H), 6.41 (s, 1H), 4.89 (d, *J* = 15.5 Hz, 1H), 4.72 (d, *J* = 15.5 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 164.0, 162.0, 153.9, 141.3, 137.3, 134.3, 129.8, 128.5, 127.5, 127.4, 125.9, 125.9, 125.3, 124.6, 123.1, 121.9, 120.6, 116.7, 116.4, 116.2, 111.7, 65.5, 53.0, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{19}F_4NO_2Na$ 488.1250; Found 488.1256.

1-(2-(4-propylphenyl)-4-(4-(trifluoromethyl)phenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3u)

Yield: 28 mg, 47% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3056, 1666, 1606, 1065**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.64 (d, *J* = 8.0 Hz, 2H), 7.59 (d, *J* = 8.0 Hz, 2H), 7.41 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.25 – 7.21 (m, 1H), 7.10 (d, *J* = 8.5 Hz, 2H), 7.04 (td, *J* = 7.5, 1.5 Hz, 3H), 6.92 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.54 (s, 1H), 6.42 (s, 1H), 4.89 (d, *J* = 15.0 Hz, 1H), 4.72 (d, *J* = 15.0 Hz, 1H), 2.56 – 2.53 (m, 2H), 1.73 (s, 3H), 1.62 – 1.57 (m, 2H), 0.91 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.4, 153.9, 143.9, 141.5, 138.5, 135.5, 129.7, 129.2, 128.6, 125.8, 125.8, 125.7, 125.3, 124.2, 123.2, 121.8, 120.8, 116.6, 111.0, 65.6, 53.0, 37.7, 24.7, 24.3, 13.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{30}H_{26}F_3NO_2Na$ 512.1813; Found 512.1823.

1-(2-phenyl-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3v)

Yield: 23 mg, 50% yield, as colorless foam**;** R_f = 0.23 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2922, 1648, 1605, 1033**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.39 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.31 – 7.28 (m, 3H), 7.27 (dd, *J* = 5.5, 1.5 Hz, 1H), 7.22 – 7.18 (m, 3H), 7.13 (d, *J* = 3.5 Hz, 1H), 7.01 (td, *J* = 7.5, 1.5 Hz, 1H), 6.93 (dd, *J* = 5.5, 4.0 Hz 1H), 6.90 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.66 (s, 1H), 6.45 (s, 1H), 4.89 (d, *J* = 15.0 Hz, 1H), 4.83 (d, *J* = 15.0 Hz, 1H), 1.69 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.5, 153.9, 140.3, 138.5, 138.1, 129.6, 129.0, 128.8, 128.7, 126.8, 126.8, 126.6, 126.0, 125.6, 124.2, 123.2, 121.7, 120.7, 116.6, 111.5, 65.6, 49.7, 33.6,

24.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{19}NO_2SNa$ 408.1034; Found 408.1028.

1-(4-(thiophen-2-yl)-2-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3w)

Yield: 35 mg, 74% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3069, 1665, 1606, 1040**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.38 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.25 (dd, *J* = 5.0, 1.0 Hz, 1H), 7.20 (td, *J* = 8.0, 1.5 Hz, 1H), 7.16 (s, 5H), 7.01 (td, *J* = 7.5, 1.5 Hz, 1H), 6.92 (dd,*J* = 5.5, 1.5 Hz, 1H), 6.89 (dd, *J* = 8.0, 1.0 Hz, 1H),6.65 (s, 1H), 6.41 (s, 1H), 4.88 (d, *J* = 15.5 Hz, 1H), 4.83 (d, *J* = 15.5 Hz, 1H), 2.32 (s, 3H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.7, 153.8, 140.3, 138.9, 138.1, 135.7, 129.7, 129.5, 126.8, 126.7, 126.5, 125.9, 125.3, 124.2, 123.2, 121.7, 120.8, 116.5, 110.8, 65.6, 49.7, 24.8, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{25}H_{21}NO_2SNa$ 422.1191; Found 422.1188.

1-(2-(4-bromophenyl)-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3x)

Yield: 21 mg, 38% yield, as colorless foam**;** R_f = 0.23 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1670, 1586, 1072**; ^{1}H NMR (500 MHz, $CDCl_3$):** 7.45 (d, *J* = 8.5 Hz, 2H), 7.37 (dd, *J* = 7.5, 1.3 Hz, 1H), 7.27 (dd, *J* = 5.0, 1.0 Hz, 1H), 7.21 (td, *J* =8.0, 1.5 Hz, 1H), 7.12 (d, *J* = 3.5 Hz, 1H), 7.09 (d, *J* = 6.0 Hz, 2H), 7.01 (td, *J* = 7.5, 1.1 Hz, 1H), 6.93 (dd, *J* = 5.10, 3.5 Hz, 1H), 6.90 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.65 (s, 1H), 6.45 (s, 1H), 4.88 (d, *J* = 15.0 Hz, 1H), 4.83 (d, *J* = 15.5 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.3, 153.8, 140.0, 137.4, 137.0, 132.3, 129.7, 127.4, 126.9, 126.7, 126.1, 124.1, 123.2, 122.8, 121.8, 120.6, 116.6, 112.1, 65.5, 49.6, 24.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{18}BrNO_2SNa$ 486.0139; Found 486.0132.

1-(2-(4-fluorophenyl)-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3y)

Yield: 12 mg, 24% yield, as colorless foam**;** R_f = 0.37 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3072, 1670, 1599, 1229**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ7.37 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.28 (dd, *J* = 5.5, 1.5 Hz, 1H), 7.23 – 7.19 (m, 3H), 7.13 (d, *J* = 3.5, Hz, 1H), 7.06 – 6.99

(m, 3H), 6.94 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.90 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.65 (s, 1H), 6.40 (s, 1H), 4.89 (d, *J* = 15.5Hz, 1H), 4.83 (d, *J* = 15.0 Hz, 1H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.4, 163.9, 161.9, 153.8, 140.2, 137.0, 134.7, 129.6, 127.8, 127.7, 126.9, 126.6, 125.6, 124.2, 123.1, 121.7, 120.6, 116.6, 116.2, 116.1, 111.5, 65.5, 49.7, 24.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{18}FNO_2SNa$ 426.0940; Found 426.0930.

1-(2-(4-propylphenyl)-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3z)

Yield: 24 mg, 47% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3070, 1667, 1606, 1040**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.39 (d, *J* = 8.5Hz, 1H), 7.26 – 7.25 (m, 1H), 7.20 (td, *J* = 8.0, 1.5 Hz, 1H), 7.12 (s, 5H), 7.01 (t, *J* = 7.5Hz, 1H), 6.92 (dd, *J* = 5.0, 3.5 Hz1H), 6.90 (d, *J* = 8.0 Hz, 1H), 6.65 (s, 1H), 6.42 (s, 1H), 4.89 (d, *J* = 15.0 Hz, 1H), 4.84 (d, *J* = 15.0 Hz, 1H), 2.55 (t, *J* = 7.5 Hz, 2H), 1.70 (s, 3H), 1.63 – 1.57 (m, 2H), 0.92 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.7, 153.8, 143.6, 140.4, 138.2, 135.9, 129.5, 129.1, 126.8, 126.8, 126.5, 125.9, 125.2, 124.2, 123.2, 121.7, 120.8, 116.5, 110.7, 65.6, 49.7, 37.7, 26.9, 24.8, 24.4, 13.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{25}NO_2SNa$ 450.1504; Found 450.1512.

1-(4-(thiophen-2-yl)-2-(thiophen-3-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3aa)

Yield: Trace, **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{22}H_{17}NO_2S_2Na$ 414.0598; Found 414.0599.

1-(9-fluoro-2,4-diphenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ab)

Yield: 30 mg, 63% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1665, 1591, 1074**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.49 (d, *J* = 7.0 Hz, 2H), 7.36 – 7.30 (m, 3H), 7.28 – 7.27 (m, 3H), 7.13 (s, 2H), 7.09 (dd, *J* = 9.0, 3.0 Hz, 1H), 6.92 – 6.88 (m, 1H), 6.86 (dd, *J* = 9.0, 5.5 Hz, 1H), 6.53 (s, 1H), 6.34 (s, 1H), 4.86 (d, *J* = 15.5 Hz, 1H), 4.74 (d, *J* = 15.5 Hz, 1H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.0, 158.8, 156.9, 149.7, 138.7, 138.3, 137.0, 129.0, 128.9, 128.8, 128.6, 128.1, 127.0, 125.8, 124.2, 122.1, 117.4, 117.3,

115.5, 115.3, 111.4, 109.8, 109.6, 65.8, 53.4, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}FNO_2Na$ 420.1376; Found 420.1368.

1-(9-fluoro-4-phenyl-2-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ac)

Yield: 33 mg, 67% yield, as colorless foam**;** R_f = 0.22 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3060,1667, 1589, 1025**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.48 (d, *J* = 7.0 Hz, 2H), 7.34 – 7.27 (m, 3H), 7.10 – 7.07 (m, 3H), 7.02 (s, 2H), 6.89 (td, *J* = 8.5, 3.0 Hz, 1H), 6.85 (dd, *J* = 9.0, 5.0 Hz, 1H), 6.52 (s, 1H), 6.30 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.73 (d, *J* = 15.5 Hz, 1H), 2.30 (s, 3H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 158.8, 156.9, 149.7, 139.0, 138.8, 137.0, 135.5, 129.7, 128.9, 128.5, 128.1, 125.7, 124.4, 122.2, 122.1, 117.4, 117.3, 115.4, 115.3, 110.7, 109.8, 109.6, 65.9, 53.4, 24.8, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{22}FNO_2Na$ 434.1532; Found 434.1522.

1-(2-(4-bromophenyl)-9-fluoro-4-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ad)

Yield: 22 mg, 39% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1669, 1489, 1073, 1032; **^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.46 (d, *J* = 7.0 Hz, 2H), 7.41 (d, *J* = 8.5 Hz, 2H), 7.35 – 7.30 (m, 3H), 7.07 (dd, *J* = 9.0, 3.0 Hz, 1H), 6.99 (d, *J* = 7.0 Hz, 2H), 6.91 (td, *J* = 8.5, 3.0 Hz, 1H), 6.86 (dd, *J* = 9.0, 5.5 Hz, 1H), 6.52 (s, 1H), 6.35 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.73 (d, *J* = 15.5 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.7, 158.8, 156.9, 149.7, 137.6, 137.2, 136.8, 132.3, 129.0, 128.7, 128.0, 127.2, 124.3, 122.9, 117.4, 117.4, 115.6, 115.5, 112.0, 109.8, 109.6, 65.8, 53.4, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{19}BrFNO_2Na$ 498.0481; Found 498.0472.

1-(9-fluoro-2-(4-fluorophenyl)-4-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ae)

Yield: 25 mg, 51% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3064, 1669, 1597, 1099, 1024**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.48 (d, *J* = 7.0 Hz, 2H), 7.36 – 7.29 (m, 3H), 7.09 – 7.06 (m, 3H), 6.98 (t, *J* = 9.0 Hz, 2H), 6.90 (td, *J* = 9.0, 3.0 Hz, 1H), 6.86 (dd, *J* = 9.0, 5.0 Hz, 1H), 6.52 (s, 1H), 6.29 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.73 (d, *J* = 15.5 Hz, 1H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.8, 163.9, 161.9, 158.8,

156.9, 149.7, 137.6, 136.9, 129.0, 128.7, 128.0, 127.5, 127.4, 127.1, 117.4, 117.3, 116.3, 116.1, 115.6, 115.4, 111.4, 109.8, 109.6, 65.8, 53.4, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{19}F_2NO_2Na$ 438.1282; Found 438.1265.

1-(9-fluoro-4-phenyl-2-(4-propylphenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3af)

Yeild: 26 mg, 50% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1669, 1591, 1549, 1041**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.49 (d, *J* = 7.0 Hz, 2H), 7.35 – 7.29 (m, 3H), 7.08 (d, *J*= 6.5 Hz, 3H), 7.04 (s, 2H), 6.90 (t, *J* = 8.5 Hz, 1H), 6.87 – 6.83 (m, 1H), 6.52 (s, 1H), 6.31 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.74 (d, *J* = 15.5 Hz, 1H), 2.54 (t, *J* = 8.0 Hz, 2H), 1.71 (s, 3H), 1.61 – 1.56 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 158.8, 156.9, 149.7, 143.7, 138.8, 137.1, 135.7, 129.1, 128.9, 128.5, 128.1, 126.7, 125.7, 124.4, 122.1, 117.4, 117.3, 115.4, 115.2, 110.6, 109.8, 109.6, 65.9, 53.4, 37.7, 24.8, 24.4, 13.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{26}FNO_2Na$ 462.1845; Found 462.1848.

1-(9-fluoro-4-phenyl-2-(thiophen-3-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ag)

Yield: 16 mg, 33% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3066, 1664, 1490, 1079**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.47 (d, *J* = 7.0 Hz, 2H), 7.34 – 7.26 (m, 4H), 7.05 (dd, *J* = 9.0, 3.0 Hz, 1H), 7.03 (d, *J* = 2.5 Hz, 1H), 6.93 (d, *J* = 5.5 Hz, 1H), 6.89 (dd, *J* = 8.5, 3.0 Hz, 1H), 6.86 (dd, *J* = 8.5, 5.0 Hz, 1H), 6.48 (s, 1H), 6.32 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.75 (d, *J* = 15.5 Hz, 1H), 1.81 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 158.8, 156.9, 149.7, 140.1, 137.2, 134.1, 128.9, 128.5, 127.8, 127.1, 125.4, 124.3, 122.2, 117.4, 117.3, 115.5, 115. 3, 110.2, 109.8, 109.6, 65.9, 53.3, 24.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{18}FNO_2SNa$ 426.0940; Found 426.0929.

1-(9-fluoro-2-phenyl-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-c]pyridin-3-yl)ethanone (3ah)

Yield: Trace, **HRMS (ESI – Orbitrap) m/z:** $[M-1]^+$ Calcd for $C_{27}H_{22}FNO_2$ 410.1556; Found 410.1546.

1-(2-(4-bromophenyl)-9-fluoro-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ai)

Yield: 21 mg, 36% yield, as colorless foam**;** R_f = 0.23 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3058, 1666, 1589, 1073; **^{1}H NMR (500 MHz, $CDCl_3$):** 7.42 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 7.0 Hz, 2H), 7.26 (d, *J* = 1.5 Hz, 1H), 7.13 (d, *J* = 7.5 Hz, 2H), 7.06 (d, *J* = 8.5 Hz, 1H), 7.01 (d, *J* = 5.0 Hz, 1H), 6.91 – 6.83 (m, 2H), 6.48 (s, 1H), 6.34 (s, 1H), 4.84 (d, *J* = 15.0 Hz, 1H), 4.72 (d, *J* = 15.0 Hz, 1H), 2.32 (s, 3H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.7, 158.8, 156.8, 149.7, 138.5, 137.5, 137.3, 133.7, 132.3, 129.7, 127.9, 127.2, 124.1, 122.8, 121.9, 121.9, 117.4, 117.3, 115.6, 115.4, 112.0, 109.8, 109.6, 65.8, 53.2, 24.7, 21.2; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{21}BrFNO_2Na$ 512.0637; Found 512.0627.

1-(9-fluoro-2-phenyl-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3aj)

Yield: 31 mg, 64% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3070, 1666, 1590, 1177**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.33– 7.30 (m, 3H), 7.28 (dd, *J* = 5.0, 1.5 Hz, 1H), 7.22 (s, 2H), 7.12 (d, *J* = 3.5 Hz, 1H), 7.09 (dd, *J* = 9.0, 3.0 Hz, 1H), 6.94 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.90 (td, *J* = 9.0, 3.0 Hz, 1H), 6.85 (dd, *J* = 9.0, 5.0 Hz, 1H), 6.68 (s, 1H), 6.35 (s, 1H), 4.86 (d, *J* = 15.5 Hz, 1H), 4.81 (d, *J* = 15.0 Hz, 1H) 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.6, 158.8, 156.9, 149.71, 140.0, 138.5, 138.3, 129.1, 126.9, 126.7, 126.0, 123.8, 121.9, 121.9, 117.4, 117.4, 115.7, 115.5, 110.9, 109.9, 109.8, 65.6, 49.6, 24.8; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{18}FNO_2SNa$ 426.0940; Found 426.0940.

1-(9-fluoro-4-(thiophen-2-yl)-2-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)ethanone (3ak)

Yield: 21 mg, 41% yield, as colorless foam**;** R_f = 0.22 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3071, 1670, 1492, 1031**; ^{1}H NMR (500 MHz, $CDCl_3$): δ** 7.26 – 7.25 (m, 1H), 7.12 – 7.11 (m, 5H), 7.08 (dd, *J* = 9.0, 3.0 Hz, 1H), 6.93 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.90 – 6.86 (m, 1H), 6.84 (dd, *J* = 9.0, 5.0 Hz,1H) 6.67 (s, 1H), 6.32 (s, 1H), 4.85 (d, *J* = 15.5 Hz, 1H), 4.80 (d, *J* = 15.0 Hz, 1H), 2.33 (s, 3H), 1.71 (s, 3H)**; ^{13}C NMR (125MHz, $CDCl_3$): δ** 171.6, 158.8, 156.9, 149.7, 149.7, 140.0, 139.1, 138.6, 135.5, 129.8, 126.8, 126.6, 126.5, 125.9, 117.4, 117.3,

115.6, 115.4, 110.2, 110.0, 109.8, 65.7, 49.6, 24.8, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{25}H_{20}FNO_2SNa$ 440.1096; Found 440.1087.

1-(2,4-diphenyl-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3al)

Yield: 22 mg, 46% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3059, 1667, 1596, 1032**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.65 (d, *J* = 7.5 Hz, 2H), 7.51 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.36 – 7.33 (m, 3H), 7.31 (d, *J* = 7.5 Hz, 1H), 7.26 – 7.24 (m, 4H), 7.22 (dd, *J* = 3.0, 2.0 Hz, 1H), 7.20 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.13 (s, 1H), 6.62 (s, 1H), 6.40 (s, 1H), 3.83 (d, *J* = 16.0 Hz, 1H), 3.15 (d, *J* = 16.0 Hz, 1H), 1.72 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.9, 138.4, 137.7, 137.3, 133.6, 132.6, 132.2, 131.6, 129.2, 128.9, 128.7, 128.5, 128.4, 128.1, 127.8, 127.5, 126.1, 125.8, 125.1, 115.1, 57.0, 27.3, 24.6; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{21}NOSNa$ 418.1242; Found 418.1232.

1-(4-phenyl-2-(*p*-tolyl)-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3am)

Yield: 13 mg, 26% yield, as colorless foam**;** R_f = 0.21 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2925, 1663, 1371, 1039**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.64 (d, *J* = 7.0 Hz, 2H), 7.50 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.36 – 7.32 (m, 3H), 7.29 (d, *J* = 7 Hz, 1H), 7.23 – 7.21 (m, 1H), 7.19 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.06 (d, *J* = 8.5 Hz, 2H), 7.02 (d, *J* = 7.0 Hz, 2H), 6.61 (s, 1H), 6.36 (s, 1H), 3.83 (d, *J* = 16.0 Hz, 1H), 3.15 (d, *J* = 16.0 Hz, 1H), 2.29 (s, 3H), 1.73 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.0, 138.6, 137.7, 137.3, 135.5, 133.6, 132.6, 132.3, 131.6, 129.6, 129.2, 128.7, 128.4, 128.4, 128.0, 127.8, 127.2, 126.1, 125.7, 125.1, 114.4, 57.0, 27.3, 24.6, 21.1**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{23}NOSNa$ 432.1398; Found 432.1406.

1-(2-(4-bromophenyl)-4-phenyl-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3an)

Yield: 18 mg, 31% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3059, 1668, 1584, 1072, 1035**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.62 (d, *J* = 7.0 Hz, 2H), 7.48 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.39 (d, *J* = 8.5 Hz, 2H), 7.37 – 7.34 (m, 2H), 7.33 – 7.30 (m, 2H), 7.23 (dd, *J* = 7.5, 2.0 Hz 1H), 7.20 (dd, *J* = 7.5, 1.5 Hz, 1H), 6.99 (d, *J* = 7.5 Hz, 2H), 6.61 (s, 1H), 6.40 (s, 1H), 3.82 (d, *J* = 15.5 Hz, 1H), 3.14 (d, *J* = 15.5 Hz, 1H), 1.74 (s, 3H)**; ^{13}CNMR**

(125 MHz, $CDCl_3$): δ 171.7, 137.3, 137.1, 136.6, 132.6, 132.2, 132.1, 129.1, 128.8, 128.6, 128.3, 128.2, 128.1, 127.9, 127.1, 126.1, 125.1, 122.6, 115.7, 56.9, 27.3, 24.6; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}BrNOSNa$ 496.0347; Found 496.0346.

1-(2-(4-fluorophenyl)-4-phenyl-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3ao)

Yield: 20 mg, 40% yield, as colorless foam**;** R_f = 0.22 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3061, 1668, 1598, 1077, 1034**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.64 (d, *J* = 7.0 Hz, 2H), 7.49 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.36 (t, *J* = 8.0 Hz, 3H), 7.32 (d, *J* = 7.0 Hz, 1H), 7.23 (td, *J* = 8.0, 2.0 Hz, 2H), 7.09 (s, 2H), 6.96 (t, *J* = 8.5 Hz, 2H), 6.61 (s, 1H), 6.35 (s, 1H), 3.83 (d, *J* = 16.0 Hz, 1H), 3.15 (d, *J* = 16.0 Hz, 1H), 1.72 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** 171.8, 163.8, 161.8, 137.2, 132.6, 132.2, 129.1, 128.8, 128.5, 128.3, 128.1, 127.9, 127.5, 127.4, 126.1, 125.1, 116.1, 116.0, 115.1, 57.0, 27.3, 24.6**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{20}FNOSNa$ 436.1147; Found 436.1149.

1-(4-phenyl-2-(4-propylphenyl)-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3ap)

Yield: 12 mg, 23% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3058, 1668,1605, 1035**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.65 (d, *J* = 7.5 Hz, 2H), 7.51 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.36 – 7.33 (m, 3H), 7.30 (d, *J* = 7.5 Hz, 1H), 7.23 – 7.18 (m, 2H), 7.07 – 7.03 (m, 4H), 6.61 (s, 1H), 6.36 (s, 1H), 3.83 (d, *J* = 15.5 Hz, 1H), 3.15 (d, *J* = 16.0 Hz, 1H), 2.54 – 2.51 (m, 2H), 1.72 (s, 3H), 1.60 – 1.56 (m, 2H), 0.90 (t, *J* = 7.5 Hz, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 172.1, 143.4, 137.8, 137.4, 135.8, 132.6, 132.3, 129.0, 128.7, 128.4, 128.3, 128.0, 127.8, 127.1, 126.1, 125.7, 125.1, 114.3, 57.0, 37.7, 27.4, 24.6, 24.4, 13.8; **HRMS (ESI – Orbitrap) m/z:** $[M-1]^+$Calcd for $C_{29}H_{27}NOS$ 436.1735; Found 437.1741.

1-(4-phenyl-2-(thiophen-3-yl)-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)ethanone (3aq)

Yield: 18, 39% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3103, 1670, 1588, 1230**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.63 (d, *J* = 7.0 Hz, 2H), 7.47 – 7.45 (m, 1H), 7.36 (dd, *J* = 7.5, 2.0 Hz, 2H), 7.33 (d, *J* = 7.5 Hz, 2H), 7.25 – 7.24 (m, 1H), 7.23 – 7.20 (m, 2H), 7.02 (d, *J* = 1.5 Hz, 1H), 6.92 (dd, *J* = 5.0, 1.0 Hz, 1H), 6.56 (s, 1H), 6.37 (s, 1H), 3.83 (d, *J* = 15.5 Hz, 1H), 3.15 (d, *J* = 16.0 Hz, 1H), 1.83 (s, 3H)**; ^{13}C NMR (125 MHz,**

$CDCl_3$): δ 172.0, 140.2, 137.5, 132.6, 132.2, 129.1, 128.7, 128.3, 128.1, 128.1, 127.8, 127.4, 126.9, 126.1, 125.5, 125.1, 121.8, 113.9, 56.9, 27.5, 24.0**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{24}H_{19}NOS_2Na$ 424.0806; Found: 424.0803.

General procedure for $BF_3.OEt_2$ mediatedsynthesis of *N*-acetylated pyrano / thiopyranopyridines (5)

To a mixture of 1 equiv of (3*E*,5*E*)-3,5-diarylidenedihydro-2*H*-pyran-4(3*H*)-one / (3*Z*,5*Z*)-3,5-diarylidene dihydro-2*H*-thiopyran-4(3*H*)-one (0.12 mmol) and 3 equiv of aryl or hetero aryl alkyne (0.36 mmol) in acetonitrile (2 ml) with 2 equiv of water at 50 ^oC added 3 equiv of $BF_3.OEt_2$ (0.36 mmol). The reaction mixture was then allowed to stir for 10 - 90 minutes by monitoring the TLC. After the completion of reaction the reaction mixture was extracted with ethyl acetate (3 X 10 ml), evaporated in *vacuo* and purified by column chromatography using 100 – 200 mesh silica gel with ethyl acetate/ hexane as the eluent to afford the corresponding *N*-acetylated pyridine as the product.

(*Z*)-1-(6-phenyl-8-(thiophen-2-yl)-4-(thiophen-2-ylmethylene)-3,4-dihydro-1*H*-pyrano[3,4-*c*]pyridin-7(8*H*)-yl)ethanone (5a)

Yield: 40 mg, 77% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1668, 1587, 1097, 1040**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.36 (d, *J* = 5.0, Hz, 1H), 7.31 (d, *J* = 6.5 Hz, 3H), 7.26 – 7.25 (m, 1H), 7.20 (d, *J* = 4.0 Hz, 2H), 7.09 – 7.06 (m, 2H), 7.04 (d, *J* = 3.5 Hz, 1H), 6.93 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.89 (s,1H), 6.61 (s,1H), 6.43 (s,1H), 4.95 (dd, *J* = 14.5, 1.5 Hz, 1H), 4.71 (dd, *J* = 14.5, 1.5 Hz, 1H), 4.36 (s, 2H), 1.68 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.3, 140.3, 139.4, 138.5, 137.2, 133.1, 132.9, 129.0, 128.7, 128.6, 128.4, 127.6, 126.8, 126.6, 126.4, 126.1, 115.6, 111.9, 66.1, 65.9, 50.0, 24.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{25}H_{21}NO_2S_2Na$ 454.0911; Found 454.0911.

(*Z*)-1-(8-(thiophen-2-yl)-4-(thiophen-2-ylmethylene)-6-(*p*-tolyl)-3,4-dihydro-1*H*-pyrano[3,4-*c*]pyridin-7(8*H*)-yl)ethanone (5b)

Yield: 21 mg, 40% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1669, 1587, 1183**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.35 (dd, *J* = 5.5, 1.0 Hz, 1H), 7.24 (dd, *J* = 5.0 Hz, 1.0 Hz, 1H), 7.10 (s, 3H), 7.08 (dd, *J* = 5.0, 4.0 Hz, 2H), 7.06 – 7.02 (m, 2H), 6.92 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.88 (s, 1H), 6.60 (s, 1H), 6.39 (s, 1H), 4.94 (dd, *J*

= 14.5, 1.5 Hz, 1H), 4.71 (dd, *J* = 14.5, 2.0 Hz, 1H), 4.36 (s, 2H), 2.32 (s, 3H), 1.69 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.4, 140.3, 139.4, 138.8, 137.2, 135.7, 132.7, 129.7, 129.1, 128.4, 127.6, 126.7, 126.7, 126.6, 126.3, 125.9, 125.8, 115.5, 112.4, 111.1, 66.13, 65.9, 50.0, 24.7, 21.2; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{23}NO_2S_2Na$ 468.1068; Found 468.1074.

(*Z*)-1-(4-benzylidene-6,8-diphenyl-3,4-dihydro-1*H*-thiopyrano[3,4-*c*]pyridin-7(8*H*)-yl)ethanone (5c)

Yield: 17 mg, 33% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3058, 1665, 1599, 1054, 1030**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.44 (d, *J* = 7.5 Hz, 2H), 7.41 (t, *J* = 8.0 Hz, 2H), 7.34 – 7.28 (m, 7H), 7.24 – 7.23 (m, 2H), 7.08 (s, 2H), 6.96 (s, 1H), 6.48 (s, 1H), 6.41 (s, 1H), 3.74 (d, *J* = 14.5 Hz, 1H), 3.69 (d, *J* = 14.5 Hz, 1H) 3.50 (d, *J* = 18.5 Hz, 1H), 3.36 (d, *J* = 18.5 Hz, 1H), 1.70 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ171.7, 138.4, 137.3, 136.8, 136.5, 131.5, 131.4, 129.6, 129.3, 128.9, 128.8, 128.5, 128.3, 128.2, 127.3, 125.8, 125.6, 115.0, 57.7, 29.2, 27.1,24.5; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{25}NOSNa$ 458.1555; Found 458.1560.

(*Z*)-1-(4-benzylidene-8-phenyl-6-(*p*-tolyl)-3,4-dihydro-1*H*-thiopyrano[3,4-*c*]pyridin-7(8*H*)-yl)ethanone (5d)

Yield: 9 mg, 17% yield, as colorless foam**;** R_f = 0.18 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3028, 1665, 1607, 1033**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ7.44 (d, *J* = 7.5 Hz, 3H), 7.40 (d, *J* = 7.5 Hz, 2H), 7.33 (t, *J* = 7.5 Hz, 5H), 7.05 (d, *J* = 8.0 Hz, 2H), 6.98 (d, *J* = 7.0 Hz, 2H), 6.95 (s, 1H), 6.47 (s, 1H), 6.37 (s, 1H), 3.73 (d, *J* = 14.5 Hz, 1H), 3.69 (d, *J* = 14.5 Hz, 1H), 3.49 (d, *J* = 18.0 Hz, 1H), 3.37 (d, *J* = 18.5 Hz, 1H), 2.29 (s, 3H), 1.71 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ171.8, 138.6, 137.3, 136.8, 136.5, 135.5, 131.4, 131.2, 129.7, 129.6, 129.3, 128.7, 128.5, 128.2, 127.2, 125.7, 125.5, 114.3, 57.6, 29.2, 27.1, 24.6, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{30}H_{27}NOSNa$ 472.1711; Found 472.1710.

(*Z*)-1-(6-phenyl-8-(thiophen-2-yl)-4-(thiophen-2-ylmethylene)-3,4-dihydro-1*H*-thiopyrano[3,4-*c*]pyridin-7(8*H*)-yl)ethanone (5e)

Yield: 33 mg, 61% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3069, 1666, 1592, 1036**; ^{1}H NMR (500 MHz, $CDCl_3$): δ** 7.37 (dd, *J* = 5.5, 1.5 Hz,

1H), 7.30 – 7.29 (m, 3H), 7.26 (dd, *J* = 5.0, 1.5 Hz, 1H), 7.20 (d, *J* = 6.0 Hz, 2H), 7.14 (d, *J* = 3.5 Hz, 1H), 7.10 – 7.07 (m, 2H), 7.00 (s, 1H), 6.93 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.62 (s, 1H), 6.38 (s, 1H), 3.86 (s, 2H), 3.49 (d, *J* = 18.0 Hz, 1H), 3.41 (d, *J* = 18.0 Hz, 1H), 1.68 (s, 3H)**; ^{13}C NMR (126 MHz, $CDCl_3$):** δ 171.2, 140.2, 139.5, 138.3, 136.6, 132.2, 129.5, 129.1, 129.0, 129.0, 128.6, 127.4, 126.9, 126.7, 126.6, 126.4, 126.1, 118.7, 114.5, 53.9, 28.6, 27.6, 24.6**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{25}H_{21}NOS_3Na$ 470.0683; Found 470.0683.

(*Z*)-1-(8-(thiophen-2-yl)-4-(thiophen-2-ylmethylene)-6-(*p*-tolyl)-3,4-dihydro-1*H*-thiopyrano[3,4-c]pyridin-7(8*H*)-yl)ethanone (5f)

Yield: 24 mg, 43% yield, as colorless foam**;** R_f = 0.15 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3026, 1667, 1510, 1038**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.37 (dd, *J* = 5.0, 1 Hz, 1H), 7.24 (dd, *J* = 5.5, 1.5 Hz, 1H), 7.13 (d, *J* = 3.5 Hz, 1H), 7.10 – 7.06 (m, 6H), 6.99 (s, 1H), 6.92 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.61 (s, 1H), 6.34 (s, 1H), 3.86 (s, 2H), 3.48 (d, *J* = 18.5 Hz, 1H), 3.41(d, *J* = 18.0 Hz, 1H), 2.32 (s, 3H), 1.69 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$)**: δ 171.3, 140.3, 139.6, 138.7, 136.6, 135.5, 132.0, 129.6, 129.2, 128.9, 127.4, 126.9, 126.7, 126.5, 126.3, 126.0, 118.7, 113.8, 53.9, 31.6, 28.6, 27.6, 24.6, 21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{26}H_{23}NOS_3Na$ 484.0839; Found: 484.0834.

General procedure for $BF_3.OEt_2$ mediated synthesis of *N*-substituted chromeno / thiochromeno pyridines (7)

To a mixture of 1 equiv of substituted arylidene chroman-4-one/thiochroman-4-one (0.12 mmol) and 3 equiv of aryl or hetero aryl alkyne (0.36 mmol) in respective nitrile (2 ml) with 2 equiv of water at 50 ^oC added 3 equiv of $BF_3.OEt_2$ (0.36 mmol). The reaction mixture was then allowed to stir for 10 - 90 minutes by monitoring the TLC. After the completion of reaction the reaction mixture was extracted with ethyl acetate (3 X 10 ml), evaporated in *vacuo* and purified by column chromatography using 100 – 200 mesh silica gel with ethyl acetate/ hexane as the eluent to afford the product.

(2,4-diphenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl) (phenyl)methanone (7a)

Yield: 27 mg, 51% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3062, 1675, 1485, 1028**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ7.69 (d, *J* = 7.5 Hz, 2H), 7.46 (dd, *J* = 7.5, 1.0 Hz, 1H), 7.38 (t, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 7.0 Hz, 1H), 7.27 (d, *J* = 7.5 Hz, 2H), 7.24 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 7.06 (t, *J* = 7.5 Hz, 3H), 6.96 – 6.91 (m, 4H), 6.77 (d, *J* = 6.5 Hz, 2H), 6.39 (s, 1H), 6.32 (s, 1H), 5.00 (d, *J* = 15.5 Hz, 1H), 4.84 (d, *J* = 15.0 Hz, 1H); **^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.2, 153.9, 139.8, 138.4, 137.2, 136.7, 130.3, 129.5, 128.9, 128.6, 128.4, 128.2, 128.0, 127.8, 127.7, 126.1, 124.7, 124.6, 123.1, 121.7, 120.9, 116.6, 109.7, 65.9, 55.6**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{31}H_{23}NO_2Na$ 464.1626; Found 464.1629.

(4-(4-chlorophenyl)-2-phenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl) (phenyl)methanone (7b)

Yield: 27 mg, 47% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3059, 1651, 1599, 1091, 1016; **^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.64 (d, *J* = 8.5 Hz, 2H), 7.46 (d, *J* = 6.5, 1H), 7.35 (d, *J*= 8.5 Hz, 2H), 7.27 – 7.25 (m, 3H), 7.14 (t, *J* = 7.5 Hz, 1H), 7.07 – 7.04 (m, 3H), 6.95 (t, *J*= 7.0 Hz, 4H), 6.76 (d,*J*= 6.0 Hz, 2H), 6.34 (s, 1H), 6.31 (s, 1H), 4.98 (d, *J* = 15.5 Hz, 1H), 4.79 (d, *J* = 15.5 Hz, 1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.3, 153.9, 139.7, 138.2, 136.5, 135.7, 134.5, 130.5, 129.9, 129.7, 129.1, 128.2, 128.1, 127.9, 127.7, 126.1, 125.0, 123.9, 123.2, 121.8, 120.8, 116.7, 109.5,65.7, 55.0; **HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{31}H_{22}ClNO_2Na$ 498.1237; Found 498.1250.

phenyl(2-phenyl-4-(*p*-tolyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)methanone (7c)

Yield: 26 mg, 47% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2924, 1650,1456, 1122**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.56 (d, *J* = 8.0 Hz, 2H), 7.46 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.27 (d, *J* = 8.5 Hz, 2H), 7.23 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.17 (d, *J* = 8.0 Hz, 2H), 7.13 (t, *J* = 7.5 Hz, 1H), 7.05 (t, *J* = 7.5 Hz, 3H), 6.95 – 6.91 (m, 4H), 6.78 (d, *J* = 5.5 Hz, 2H), 6.35 (s, 1H), 6.31 (s, 1H), 4.98 (d, *J* = 15.0 Hz, 1H), 4.82 (d, *J* = 15.0 Hz, 1H), 2.33 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.2, 153.9, 138.5, 138.4, 136.8, 134.1, 130.3, 129.6, 129.5, 128.3, 128.2, 128.0, 127.7, 127.7, 126.2, 124.9, 124.5, 123.1, 121.7, 116.6, 109.7, 66.0,

21.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{32}H_{25}NO_2Na$ 478.1783; Found 478.1802.

phenyl(2-phenyl-4-(4-(trifluoromethyl)phenyl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)methanone (7d)

Yield: 17 mg, 27% yield, as colorless foam; R_f = 0.25 (hexane/ethyl acetate = 90/10); **IR (neat, cm^{-1})**: 3064, 1650, 1603, 1067**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.83 (d, *J* = 8.0 Hz, 2H), 7.64 (d, *J* = 8.0 Hz, 2H), 7.48 (d, *J* = 6.5 Hz, 1H), 7.28 (d, *J* = 7.0 Hz, 3H), 7.16 – 7.12 (m, 1H), 7.09 – 7.05 (m, 3H), 6.97 – 6.93 (m, 4H), 6.77 (d, *J* = 6.0 Hz, 2H), 6.42 (s, 1H), 6.33 (s,1H), 5.00 (d, *J* = 15.5 Hz, 1H), 4.80 (d, *J* = 15.0 Hz, 1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.3, 153.9, 141.3, 139.9, 138.0, 136.4, 136.0, 130.6, 129.8, 128.8, 128.3, 128.2, 128.0, 127.8, 127.2, 126.1, 125.3, 123.4, 123.3, 121.8, 121.4, 120.7, 117.9, 116.7, 109.5, 65.7, 55.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{32}H_{22}F_3NO_2Na$ 532.1500; Found 532.1511.

phenyl(2-phenyl-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)methanone (7e)

Yield: 18 mg, 34% yield, as colorless foam**;** R_f = 0.20 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3063, 1654, 1603, 1449, 1229**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.46 (dd, *J* = 7.5, 1.5 Hz, 1H), 7.32 (d, *J* = 6.0 Hz, 3H), 7.25 – 7.24 (m, 2H), 7.15 (t, *J* = 8.0 Hz, 1H), 7.07 – 7.03 (m, 3H), 6.97 – 6.93 (m, 5H), 6.86 (d, *J* = 3.5 Hz, 2H), 6.51 (s, 1H), 6.32 (s, 1H), 4.99 (d, *J* = 15.5 Hz, 1H), 4.92 (d, *J* = 15.0 Hz, 1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 170.9, 153.9, 140.1, 139.5, 138.4, 130.6, 129.6, 128.4, 128.1, 127.8, 127.7, 127.2, 126.9, 126.8, 124.4, 124.2, 123.3, 121.7, 120.8, 116.7, 65.7, 51.7**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{21}NO_2SNa$ 470.1191; Found 470.1192.

(9-fluoro-2-phenyl-4-(thiophen-2-yl)-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl) (phenyl)methanone (7f)

Yield: 16 mg, 29% yield, as colorless foam**;** R_f = 0.22 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3064, 1687, 1652, 1076, 1023**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.66 – 7.65 (m, 1H,), 7.47 (t, *J* = 8.0 Hz, 1H), 7.32 – 7.30 (m, 2H), 7.25 – 7.24 (m, 1H), 7.15 (dd, *J* = 9.0, 3.0 Hz, 2H), 7.07(t, *J* = 7.5 Hz, 2H), 6.98 – 6.95 (m, 4H), 6.92 – 6.85 (m, 3H), 6.53 (s, 1H), 6.22 (s,1H),

4.96 (d, *J* = 15.5 Hz ,1H), 4.88 (d, *J* = 15.0 Hz ,1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 170.8, 158.8, 156.9, 149.8, 140.0, 139.9, 138.2, 136.3, 132.2, 130.6, 129.1, 128.6, 128.4, 128.1, 128.0, 127.7, 127.3, 127.0, 126.9, 126.3, 125.4, 117.5, 115.7, 115.5, 110.1, 109.9, 108.6, 69.1, 65.8**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{29}H_{20}FNO_2SNa$ 488.1096, Found 488.1101.

(2,4-diphenyl-4,5-dihydro-3*H*-thiochromeno[3,4-*c*]pyridin-3-yl)(phenyl)methanone (7g)

Yield: 22 mg, 40% yield, as colorless foam**;** R_f = 0.25 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 3060, 1655, 1528, 1076**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.82 (d, *J* = 7.5 Hz, 2H), 7.66 – 7.65 (m, 1H), 7.59 (d, *J* = 7.5 Hz, 1H), 7.47 (t, *J* = 7.5 Hz, 1H), 7.40 – 7.37 (m, 3H), 7.34 (d, *J* = 7.5 Hz, 1H), 7.30 – 7.27 (m, 2H), 7.23 – 7.22 (m, 1H), 7.14 (t, *J* = 7.5 Hz, 1H), 7.06 (t, *J* = 7.5 Hz, 2H), 6.91 (d, *J* = 6.0 Hz, 2H), 6.78 (d, *J* = 5.5 Hz, 2H), 6.52 (s, 1H), 6.29 (s, 1H), 3.91 (d, *J* = 15.5 Hz, 1H), 3.25 (d, *J* = 15.5 Hz, 1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 171.0, 139.2, 138.2, 137.2, 136.7, 132.8, 132.7, 132.3, 132.2, 130.3, 129.3, 129.1, 128.8, 128.7, 128.6, 128.3, 128.1, 128.0, 127.9, 127.7, 127.7, 126.4, 126.1, 126.1, 125.2, 112.9, 59.0, 27.4**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$Calcd for $C_{31}H_{23}NOSNa$ 480.1398; Found 480.1411.

1-(2,4-diphenyl-4,5-dihydro-3*H*-chromeno[3,4-*c*]pyridin-3-yl)prop-2-en-1-one (7h)

Yield: 13 mg, 28% yield, as colorless foam**;** R_f = 0.30 (hexane/ethyl acetate = 90/10)**; IR (neat, cm^{-1}):** 2922, 1654, 1602, 1038**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 7.57 (d, *J* = 7.0 Hz, 2H), 7.41 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.35 – 7.28 (m, 4H), 7.25 – 7.23 (m, 3H), 7.14 – 7.13 (m, 2H), 7.03 (td, *J* = 7.5, 1.0 Hz, 1H), 6.91 (dd, *J* = 8.0, 1.0 Hz, 1H), 6.48 (s, 2H), 6.23 (dd, *J* = 16.5, 1.5 Hz, 1H), 5.98 – 5.92 (m, 1H), 5.32 (d, *J* = 10.5 Hz, 1H), 4.90 (d, *J* = 15.5 Hz, 1H), 4.77 (d, *J* = 15.0 Hz, 1H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 167.0, 153.9, 138.7, 137.5, 137.1, 129.8, 129.5, 128.9, 128.9, 128.7, 128.5 128.2, 127.7, 125.8, 125.7, 124.7, 123.1, 121.7, 120.9, 116.5, 111.5, 65.8, 54.2**; HRMS (ESI – Orbitrap) m/z:** $[M+Na]^+$ Calcd for $C_{27}H_{21}NO_2Na$ 414.1470; Found 414.1477.

General procedure for the synthesis of 5*H*-chromeno[3,4-*c*]pyridines (9).

To a mixture of 1 equiv of substituted arylidene chroman-4-one (0.19 mmol) and 3 equiv of aryl alkyne (0.59 mmol) in acetonitrile (2 ml) with 2 equiv of water at 50 ^oC added 3 equiv of $BF_3.OEt_2$ (0.59 mmol). The reaction mixture is allowed to stir for 30 minutes. It was then cooled

to 0 °C followed by the slow addition of 1.5 equiv of 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (0.29 mmol) in acetonitrile (0.5 ml), allowed to stir at 50 °C for 6 - 12 hours. After the completion of reaction, the reaction mixture was again cooled to 0 °C, quenched with an aqueous solution of NaOH (0.2 ml, 3 M). It was then filtered and the filtrate was extracted with ethyl acetate (3 X 10 ml), evaporated in *vacuo* and purified by column chromatography using 100–200 mesh silica gel with ethyl acetate/ hexane as the eluent to afford the product.

2-phenyl-4-(*p*-tolyl)-5*H*-chromeno[3,4-*c*]pyridine (9a)

Yield: 12 mg, 17% yield, as white solid**;** R_f = 0.40 (hexane/ethyl acetate = 95/5)**; IR (neat, cm^{-1}):** 3057, 1589, 1366, 1036**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 8.14 – 8.12 (m, 2H), 7.96 (s, 1H), 7.90 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.50 – 7.48 (m, 4H), 7.43 (t, *J* = 7.5 Hz, 1H), 7.38 – 7.35 (m, 1H), 7.32 (d, *J* = 7.5 Hz, 2H), 7.16 – 7.13 (m, 1H), 7.04 (d, *J* = 8.5 Hz, 1H), 5.26 (s, 2H), 2.44 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** δ 156.7, 155.7, 139.5, 139.3, 138.7, 136.2, 131.4, 129.1, 129.0, 129.0, 128.7, 127.1, 124.2, 122.6, 122.5, 121.7, 117.6, 111.8, 65.8, 21.4**; HRMS (ESI – Orbitrap) m/z:** $[M+H]^+$ Calcd for $C_{25}H_{20}NO$ 350.1545; Found 350.1544.

4-(thiophen-2-yl)-2-(*p*-tolyl)-5*H*-chromeno[3,4-*c*]pyridine (9b)

Yield: 5 mg, 7% yield, as white solid**;** R_f = 0.36 (hexane/ethyl acetate = 95/5)**; IR (neat, cm^{-1}):** 3069, 1587, 1367, 1038**; ^{1}H NMR (500 MHz, $CDCl_3$):** δ 8.06 (d, *J* = 8.0 Hz, 2H), 7.90 (s, 1H), 7.86 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.50 (dd, *J* = 5.0, 1.0 Hz, 1H), 7.38 – 7.34 (m, 1H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.17 – 7.12 (m, 3H), 7.05 (d, *J* = 8.0 Hz, 1H), 5.47 (s, 2H), 2.43 (s, 3H)**; ^{13}C NMR (125 MHz, $CDCl_3$):** 156.4, 155.4, 148.4, 143.7, 139.4, 139.3, 136.1, 131.5, 129.5, 128.2, 127.6, 127.0, 126.8, 124.1, 122.5, 121.6, 121.4, 117.6, 111.1, 65.5, 21.4**; HRMS (ESI – Orbitrap) m/z:** $[M+H]^+$ Calcd for $C_{23}H_{18}NOS$ 356.1109; Found 356.1111.

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website.

Copies of ^{1}H, ^{13}C NMR spectra of all the newly synthesized compounds and HRMS data of 3aa, and 3ah (PDF).

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Notes

The authors declare no competing financial interest.

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