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A General Pd/Cu-Catalyzed C-H Heteroarylation of 3-Bromoquinolin-2(1*H*)-ones

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3-(heteroaryl)quinolin-2(1*H*)-ones were synthesized in good to excellent yields using a bimetallic catalytic system through C–H heteroarylation strategy. Starting from 3-bromoquinolin-2(1*H*)-ones, various azoles have been successfully used. In all cases, the reactions take place rapidly in dioxane and efficiently proceed in the presence of a bimetallic $Pd(OAc)_2$/CuI as catalysts, PPh_3 as the ligand and LiO*t*Bu or KOAc as the base.

Introduction

Biheteroaryls represent an important class of organic derivatives, which have attracted many attentions because of their multiple properties in differents areas of chemistry such as polymers, advanced materials, liquid crystals as well as pharmaceuticals.[1] One of the subfamilies of biheteroaryls is quinolin-2(1*H*)-ones or coumarins containing an heteroaryl moiety at the C3 position, whose derivatives show promising biological activities, including receptor kinase inhibitors (VEGFR/PDGFRβ[2] and checkpoint kinase Chek1[3]), adenosine A_{2B} antagonists[4] as well as hsp90 inhibitors.[5] (Figure 1) In addition, these families of biheteroaryl, particularly coumarin derivatives, are common scaffolds found in an important class of fluorophores or dyes and they have been used as powerful tools for biological applications such as live cell imaging[6] (Figure 1). As part of our continuing effort at the functionalization of heterocycles via transition metal-catalyzed reactions,[7] combined with our interest in discovering new hsp90 inhibitors,[8] we required the synthesis of C-3-heteroaryl quinolin-2(1*H*)-ones **A** (Figure 1). Traditional strategies for the preparation of such molecules, involve the construction of the heterocycle rings by nontrivial multistep reaction sequences.[2,4,9] Alternative routes involve the palladium-catalyzed Suzuki cross-coupling of heteroarylboronic acids with 3-haloquinolin-2(1*H*)-one coupling partners.[3] However, this reaction requires the preparation and use of stoichiometric amounts of heteroarylboronic acids, in which instability of the C–B bond, in some cases, lessens their synthetic utility. Therefore, it is of great interest to develop general and convergent protocols for the synthesis 3-heteroaryl quinolin-2(1*H*)-ones of type **A**.

Direct transition metal-catalyzed functionalization of C–H bonds in heteroarenes has received significant attention in modern organic chemistry due to its atom economy, high functional group tolerance and the possibilities for transformation of the unreactive C–H bonds into diverse functions in one operation.[10] In contrast to the much more developed metal-catalyzed direct arylation of various azoles with aryl halides,[11] C–H heteroarylation of heteroaromatics using heterocyclic halides as coupling partners has received much less attention.[12] Inspired by the recent advances in this field, we envisaged that the development of a general synthetic strategy for the synthesis of 3-heteroarylquinolin-2(1*H*)-one **A** through

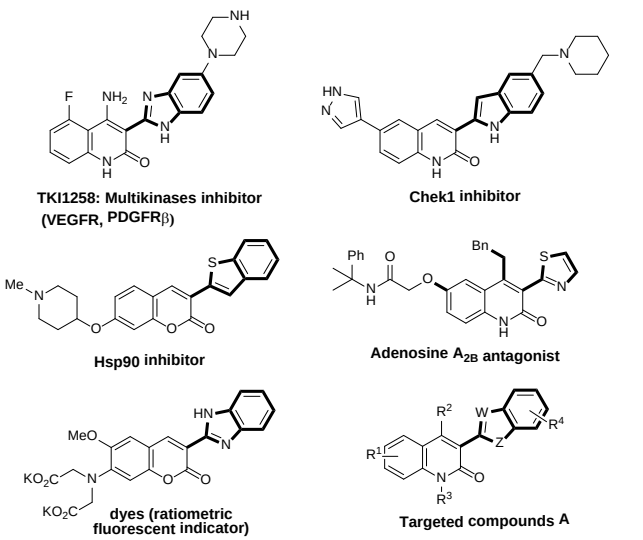

Figure 1. Chemical structures of bioactive 3-heteroaryl quinolin-2(1*H*)-ones and related heterocycles.

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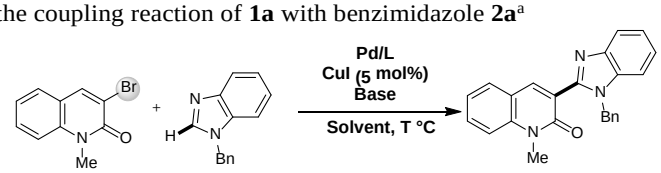
direct C-H heteroarylation of various azoles (e.g, benzimidazole, benzoxazole, benzothiazole, purine and benzothiophene) by using substituted 3-bromoquinolin-2(1*H*)-ones as the electrophilic coupling partners would be highly desirable for the purpose of medicinal chemistry screening programs. Herein, we report the details of this study.

Results and discussion

Initial investigations were performed by coupling 3-bromoquinolinone **1a** with benzimidazole **2a** as a model study (Table 1). When the reaction was performed using our previously reported procedure for the alkenylation of azoles[13] [$Pd(acac)_2$ (2.5 mol%), CuI (5 mol%), and P(*o*-tolyl)$_3$ (5 mol%); LiO*t*Bu (2 equiv) in THF at 130 °C for 12 h in sealed tube], only moderate conversion was observed (Table 1, entry 1). Achieving the reaction at 150 °C in toluene as the solvent, drives the coupling to completion, and 3-benzimidazol-2-yl-quinolin-2(1*H*)-one **3a** was obtained in a 68% yield (entry 2). It should be noted that the palladium catalyst is necessary to achieve this transformation since no reaction occurred when carrying the C–H heteroarylation in the absence of $Pd(acac)_2$. When running the reaction of **1a** and **2a** in the presence of $Pd(OAc)_2$ as the catalyst under otherwise-identical conditions, a slow rate was observed (31%, entry 3) clearly suggesting that ine the present coupling, the catalytic activity of $Pd(acac)_2$ proved to be superior to $Pd(OAc)_2$. A brief survey of phosphine ligands revealed that the nature of phosphine has an important influence in the outcome of the reaction. We were delighted to find that the use of PPh_3 in combination with $Pd(OAc)_2$ for only 1.5 h heating at 150 °C lead to the improvement of the performance of the coupling reaction with yield of **3a** up to 86% (entry 5). A similar yield was obtained when the reaction of **1a** and **2a** was performed at 130 °C (entry 6), whereas the conversion rate drops up to 17% when the reaction temperature decreases until 110 °C (entry 7). The screening reaction was continued with respect to the base. The use of LiO*t*Bu (entry 6) was found to be optimal since reactions with Cs_2CO_3 and K_2CO_3 were less efficient (entries 8-10). Of note, the use of KOAc as a base also led to total conversion, despite the fact that the coupling requires longer reaction time (12 h). Pleasingly, in this case, 3-benzimidazol-2-yl-quinolin-2(1*H*)-one **3a** was isolated in an excellent yield (91%, entry 12). A mild base such as KOAc may be useful in some cases when the substrate used is unstable or contains sensitive functionalities under basic conditions. In summary, the best conditions were found to require **1a** (1.2 equiv), **2a** (1 equiv), $Pd(AOc)_2$ (2.5 mol%), PPh_3 (5 mol%), CuI (5 mol%), LiO*t*Bu or KOAc (2 equiv), dioxane in a sealed tube at 130 °C (entries 6 and 12).

Table 1: Optimization of the coupling reaction of **1a** with benzimidazole **2a**[a]



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

Entry	[Pd]	Ligand	Base	Solvent	Temperature (°C)	Time (h)	Conv[b] (%)	Yield[c] (%)
1	$Pd(acac)_2$	P(*o*-tolyl)$_3$	LiO*t*Bu	THF	130	12	36	-
2	$Pd(acac)_2$	P(*o*-tolyl)$_3$	LiO*t*Bu	Toluene	150	12	100	68
3	$Pd(OAc)_2$	P(*o*-tolyl)$_3$	LiO*t*Bu	Toluene	150	12	31	
4	$Pd(OAc)_2$	PPh_3	LiO*t*Bu	Toluene	150	12	100	42
5	$Pd(OAc)_2$	PPh_3	LiO*t*Bu	Dioxane	150	1.5	100	86[d]
6	$Pd(OAc)_2$	PPh_3	LiO*t*Bu	Dioxane	130	1.5	100	86
7	$Pd(OAc)_2$	PPh_3	LiO*t*Bu	Dioxane	110	1.5	17	
8	$Pd(OAc)_2$	PPh_3	Cs_2CO_3	Dioxane	130	1.5	7	
9	$Pd(OAc)_2$	PPh_3	K_2CO_3	Dioxane	130	1.5	36	
10	$Pd(OAc)_2$	PPh_3	K_2CO_3	Dioxane	130	12	36	
11	$Pd(OAc)_2$	PPh_3	KOAc	Dioxane	130	1.5	38	
12	$Pd(OAc)_2$	PPh_3	KOAc	Dioxane	130	12	100	91[e]

[a)] Reaction conditions: **1a** (1.2 equiv), **2a** (1.0 equiv, 0.36 mmol), [Pd] (2.5 mol%), ligand (5 mol%), CuI (5 mol%), base (2 equiv) in solvent (1.4 mL) were heated in a sealed tube at indicated temperature. [b)] Conversion was determined by ^{1}H NMR on the crude reaction mixture, based on the chemical shift of the ^{1}H signal (ppm) of benzyl hydrogens of benzimidazole moiety (**2a:** δ = 5.15, **3a**: δ = 5.37). [c)] Yield of isolated **3a**. [d)] 39% yield of **3a** was isolated when the reaction was performed without CuI as co-catalyst.[e)] No reaction occurred without palladium catalyst and/or without PPh_3 ligand.

With a viable coupling procedure in hand, attention was turned to the generality of the process, and the couplings of structurally diverse heterocycles with some 3-bromoquinolin-2-ones **1** were studied. Remarkably, this direct heteroarylation reaction appeared to be quite general with respect to both heterocyclic partners (Schemes 2 and 3). First, we investigated the scope of the C-H heteroarylation reaction of substituted benzimidazoles with various *N*-H, *N*-methyl- and *N*-benzyl 3-bromoquinolin-2-ones. Gratifyingly, all the C-H heteroarylations proceeded cleanly and selectively in good to excellent yields regardless the nature of the substituents on the aromatic rings of quinolinone or benzimidazole moieties (compounds **3a-l**, Scheme 2). Interestingly, the reaction is effective with 3- bromoquinolin-2-ones in which the nitrogen atom is non-substituted, providing **3f** in a 76% yield. Moreover, this system could be also successfully applied to free (NH) benzimidazole leading to compounds **3e** and **3g** in 73 and 23% yields, respectively. The low yield in the case of **3g** is probably due to the very poor solubility of the substrates. Nevertheless, this

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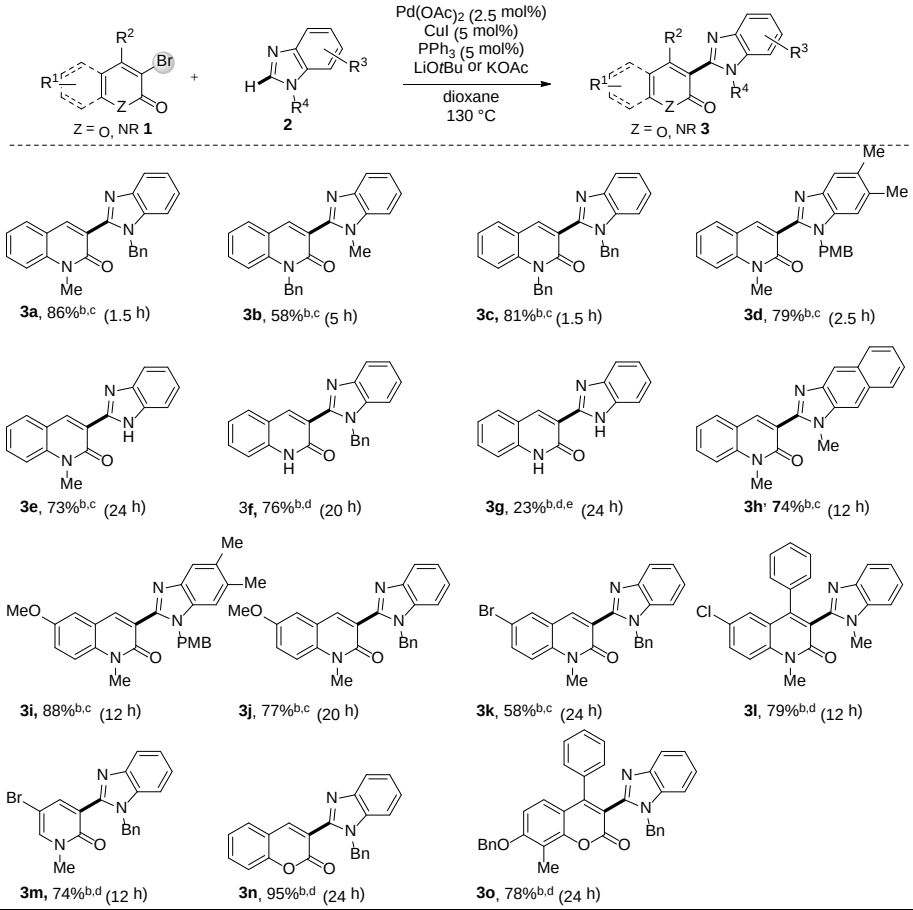
Scheme 2: Pd-Catalyzed heteroarylation of 3-bromoquinolin-2(1*H*)-ones with various benzimidazoles.[a]



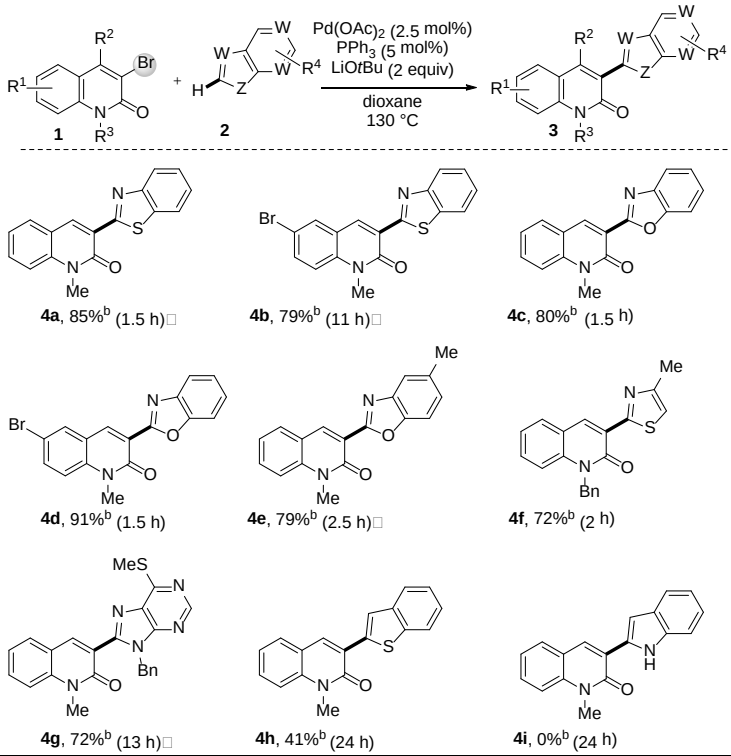
[a] Reactions of **2** (1 equiv) with quinolin-2-ones (1.2 equiv) were performed in a sealed tube at 130 °C in dioxane (0.05 M) by using $Pd(OAc)_2$ (2.5 mol%), PPh_3 (5 mol%), CuI (5 mol%), and base (Li*O*t*Bu* or KOAc) (2 equiv). Reaction time is indicated in brackets. [b] Yield of isolated product. [c] Li*O*t*Bu* was used as a base. [d] KOAc was used as a base [e] Reaction carried out at 150 °C.

compound which was prepared in one-step from commercially available starting materials was identified recently as a potent reversible ATP-competitive inhibitor of VEGFR-2, FGFR-1 and PDGFRβ kinases.[2b] This system could also be successfully applied to 3-bromoquinolone bearing a phenyl substituent on the C-4 position, indicating that the reaction does not seems to be sensitive to steric hindrance. Accordingly, 3-benzimidazol-2-yl-quinolinone **3l** was obtained in a good 79% yield. Under our optimal conditions, the reaction selectivity was investigated with quinolinone substrate containing two carbon-bromine bonds. The C–H heteroarylation proceeded at the more activated C-3 position and yielded the mono-coupling product **3k** in a satisfactory 58% yield. The selectivity of this procedure in the case of other heterocycle must be especially underlined since the reaction of 3,5-dibromopyridinone gives only 3-benzimidazoyl-5-bromopyridinone **3m** in a 74% yield. The presence of carbon–halogen bond in **3k-m** provided a handle for further structural diversifications using metal-catalyzed cross coupling reactions. Interestingly, this coupling reaction also proceeded successfully in the case of 3-bromocoumarin[14] derivatives leading to **3n** and **3o** in 95 and 78% yields,[15] respectively.

To further expand the scope of our methodology, we used this new catalytic system in direct heteroarylation of other azole heterocycles (Scheme 3). Overall, we were pleased with the generality of our protocol. The reaction proceeded in good yields with substituted benzoxazoles and benzothiazoles to afford the corresponding 3-heteroarylated quinolinones **4a-e**[16] with yields up to 91%. Remarkably, methylthiazole was regioselectively heteroarylated at the C-2 position furnishing **4f** in a good yield. *N*-benzyl purine also undergoes clean selective C8 heteroarylation as

illustrated in Scheme 3 and provided the desired coupling product **4g** in a 72% yield. It was found that the presence of SMe group on the C6 position was tolerated in **4g**, and may be useful for selective C–N[17] and C–C[18] bonds forming reaction to access to 6,8,9-trisubstitued purines of biological interest. Benzothiophene was found to be also a suitable substrate and could be heteroarylated regioselectively at C-2 position,[19] although in this case 24 h were required to obtain total conversion (compound **4h**). However, attempts to react indole as a substrate failed and only starting material was recovered unchanged.

Scheme 3 Pd-Catalyzed heteroarylation of 3-bromoquinolin-2(1*H*)-ones with various azoles.[a]



[a] Reactions of **1** (1 equiv) with quinolin-2-ones (1.2 equiv) were performed in a sealed tube at 130 °C in dioxane (0.05 M) by using $Pd(OAc)_2$ (2.5 mol%), PPh_3 (5 mol%), CuI (5 mol%), LiO*t*Bu (2 equiv). Reaction time is indicated in brackets [b] Yield of isolated product.

Conclusion

In conclusion, we developed an efficient and practical $Pd(OAc)_2/PPh_3$/CuI bimetallic catalytic system for the heteroarylation of substituted 3-bromoquinolin-2(1*H*)-ones with various azoles. This transformation exhibited broad substrate scope with respect to both the heterocyclic halides and azoles partners. It provides an attractive alternative to the existing methods for the synthesis of substituted 3-heteroarylquinolin-2(1*H*)-ones **A** and related heterocycles of biological interests. We believe that this methodology should find broad applications in synthetic organic chemistry, as well as in the combinatorial and pharmaceutical sciences.

Experimental

General experimental methods

The compounds were all identified by usual physical methods, e.g., ^{1}H NMR, ^{13}C NMR, IR, MS (ESI). ^{1}H and ^{13}C NMR spectra were measured in $CDCl_3$, DMSO-d6 with a Bruker Avance-300. ^{1}H chemical shifts are reported in ppm from an internal standard TMS or of residual solvent peak. ^{13}C chemical shifts are reported in ppm from the residual solvent peak. IR spectra were measured on a Bruker Vector 22 spectrophotometer. Analytical TLC was performed on Merck precoated silica gel 60F plates. Merck silica gel 60 (0.015–0.040 mm) was used for column chromatography. Melting points were recorded on a Büchi B-450 apparatus and are uncorrected. High resolution mass spectra (HR-MS) were recorded on a Bruker MicroTOF spectrometer, using ESI with methanol as the carrier solvent. Nominal and exact m/z values are reported in Daltons.

General procedure for C-H Heteroarylation:

A flame-dried sealed tube was charged with $Pd(OAc)_2$ (2.5 mol%), PPh_3 (5 mol%), CuI (5 mol%), quinolinone (0.43 mmol, 1.2 equiv), benzimidazole (0.36 mmol, 1 equiv) and the base (0.72 mmol, 2 equiv). The tube was capped with a rubber septum, evacuated and backfilled with argon; then, dioxane (1.4 mL) was added through the septum. The septum was replaced with a teflon screwcap. The tube was sealed, and the mixture was stirred at 130 °C until completion. The resulting suspension was cooled to room temperature and the residue was concentrated and purified by silica gel column chromatography to afford the desired product.

Analytical Data for 3-benzimidazoylquinolin-2(1*H*)-ones 3

3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)-1-methylquinolin-2(1*H*)-one 3a:

Reaction time: 1h30, 0.36 mmol scale: 113 mg, 86% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). R_f = 0.24 (Cyclohexane/EtOAc 5/5); white solid recrystallized from diisopropyl ether; m.p.= 215-217°C;IR (neat): 3056, 2933, 1641, 1594, 1572, 1456, 1396, 1214, 1072 cm^{-1}.^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.12 (s, 1H), 7.75 (d, *J* = 7.7 Hz, 1H), 7.54 (t, *J* = 8.6 Hz, 2H), 7.31 (d, *J* = 8.5 Hz, 1H), 7.25 – 7.00 (m, 7H), 6.95 (d, *J* = 7.8 Hz, 2H), 5.43 (s, 2H), 3.71 (s, 3H).^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.5(C), 150.6(C), 143.4(C), 143.0(CH), 140.6(C), 136.7(C), 136.1(C), 132.0(CH), 129.8(2CH), 128.7(CH), 127.7(2CH), 126.9(CH), 123.6(C), 123.2(CH), 122.8(CH), 122.4(CH), 120.1(CH), 120.0(C), 114.3(CH), 110.8(CH), 48.9(CH_2), 30.1(CH_3). HR-MS(ESI):m/z calcd for $C_{24}H_{20}N_3O$ $[M+H]^+$ 366.1606; found 366.1609.

1-benzyl-3-(1-methyl-1*H*-benzo[d]imidazol-2-yl)quinolin-2(1*H*)-one 3b:

Reaction time: 5h, 0.38 mmol scale: 80 mg, 58% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). R_f=0.25 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone; m.p.= 214-215°C; IR (neat): 3050, 3033, 2945, 1648, 1597, 1572, 1453, 1245, 1064 cm^{-1}.^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.36 (s, 1H), 7.82 (dd, *J* = 6.8, 2.3 Hz, 1H), 7.66 (dd, *J* = 7.8, 1.6 Hz, 1H), 7.51 (ddd, *J* = 8.8, 7.2, 1.7 Hz, 1H), 7.42 (dd, *J* = 7.0, 2.4 Hz, 1H), 7.37 – 7.19 (m, 8H), 5.64 (s, 2H), 3.82 (d, *J* = 4.3 Hz, 3H).^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 150.5(C), 149.9(C), 143.7(C), 142.8(CH), 140.3(C), 136.7(C), 136.1(C), 132.09(CH), 130.1(CH), 129.0(2CH), 127.6(CH), 126.8(2CH), 123.2(CH), 123.0(CH), 122.5(CH), 120.4(C), 119.9(CH), 116.4(CH), 115.2(CH), 109.9(CH), 46.6(CH_2), 31.9(CH_3). HR-MS(ESI):m/z calcd for $C_{24}H_{20}N_3O$ $[M+H]^+$ 366.1606; found 366.1603.

1-benzyl-3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)quinolin-2(1*H*)-one 3c:

Reaction time: 1h30, 0.36 mmol scale: 128 mg, 81% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). R_f = 0.57 (Cyclohexane/EtOAc 5/5); white solid recrystallized from diisopropyl ether; m.p.= 224-225°C; IR (neat): 3030, 1648, 1597, 1572, 1496, 1454, 1397, 1330, 1215 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.29 (s, 1H), 7.88 (d, *J* = 7.2 Hz, 1H), 7.63 (dd, *J* = 7.8, 1.0 Hz, 1H), 7.51 (t, *J* = 7.9 Hz, 1H), 7.38 – 7.15 (m, 13H), 7.05 (d, *J* = 5.8 Hz, 2H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.5(C), 150.4(C), 143.4(CH), 143.3(C), 140.0(C), 136.7(C), 136.2(C), 136.0(C), 131.9(CH), 129.9(CH), 128.9(CH), 128.7(CH), 127.6(CH), 127.4(CH), 126.7(CH), 126.7(CH), 123.5(C), 123.2(CH), 122.8(CH), 122.4(CH), 120.2(C), 120.0(CH), 115.1(CH), 110.6(CH), 48.7(CH_2), 46.4(CH_2). HR-MS(ESI):m/z calcd for $C_{30}H_{24}N_3O$ $[M+H]^+$ 442.1919; found 446.1914.

3-(1-(4-methoxybenzyl)-5,6-dimethyl-1*H*-benzo[d]imidazol-2-yl)-1-methylquinolin-2(1*H*)-one 3d:

Reaction time: 2h30, 0.28 mmol scale: 94 mg, 79% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.11 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone-MTBE (95/5); m.p.= 208-210°C; IR (neat): 3041, 2931, 1641, 1595, 1513, 1464, 1446, 1398, 1323, 1247, 1177, 1035 cm^{-1}. ^{1}H NMR (300 MHz, DMSO) δ (ppm) 8.33 (s, 1H), 7.86 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.73 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.63 (d, *J* = 8.5 Hz, 1H), 7.45 (s, 1H), 7.34 (t, *J* = 7.0 Hz, 1H), 7.24 (s, 1H), 6.95 (d, *J* = 8.7 Hz, 2H), 6.73 (d, *J* = 8.7 Hz, 2H), 5.32 (s, 2H), 3.74 (s, 3H), 3.61 (s, 3H), 2.31 (s, 3H), 2.29 (s, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 159.7(C), 158.4(C), 149.4(C), 142.3(CH), 141.5(C), 140.1(C), 134.1(C), 131.9(C), 131.2(C), 130.2(C), 129.6(CH), 129.0(C), 128.1(2CH), 123.1(C), 122.5(CH), 119.4(C), 119.2(CH), 114.9(CH), 113.8(2CH), 111.0(CH), 55.0(CH_3), 47.1(CH_2), 29.8(CH_3), 20.2(CH_3), 19.9(CH_3). HR-MS(ESI):m/z calcd for $C_{27}H_{26}N_3O_2$ $[M+H]^+$ 424.2025; found 424.2024

3-(1*H*-benzo[d]imidazol-2-yl)-1-methylquinolin-2(1*H*)-one 3e:

Reaction time: 24h, 0.85 mmol scale: 170 mg, 73% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.37 (CH_2Cl_2/MeOH 99/1); white solid recrystallized from acetone; m.p.= 182-184°C;IR (neat): 3079 1659, 1594, 1564, 1491, 1452, 1403, 1283, 1228 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.09 (s, 1H), 7.88 (d, *J* = 7.8 Hz, 1H), 7.70 – 7.54 (m, 1H), 7.48 (d, *J* = 8.3 Hz, 1H), 7.39 – 7.08 (m, 5H), 6.79 (s, 1H), 3.77 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 161.8(C), 144.2(C), 143.2(C), 142.7(C), 142.5(C), 140.8(CH), 132.5(CH), 124.9(CH), 124.4(CH), 123.5(CH), 122.9(CH), 120.9(CH), 119.0(CH), 117.5(C), 115.1(CH), 111.1(CH), 29.9(CH_3). HR-MS(ESI):m/z calcd for $C_{17}H_{14}N_3O$ $[M+H]^+$ 276.1137; found 276.1133.

3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)quinolin-2(1*H*)-one 3f:

Reaction time: 20h, 0.36 mmol scale: 96 mg, 76% yield after column chromatography (CH_2Cl_2/MeOH 95/5). R_f = 0.13 (Cyclohexane/EtOAc 5/5); light green solid; m.p.= 332-334°C; IR (neat): 3382, 2922, 2852, 1658, 1620, 1575, 1458, 1393, 1351, 1281, 1263, 1154 cm^{-1}. ^{1}H NMR (300 MHz, DMSO) δ (ppm) 12.24 (s, 1H), 8.38 (s, 1H), 7.79 (d, *J* = 7.2 Hz, 1H), 7.71 (s, 1H), 7.61 (t, *J* = 7.2 Hz, 1H), 7.48 (s, 1H), 7.41 (d, *J* = 8.1 Hz, 1H), 7.30 – 7.13 (m, 6H), 7.04 (d, *J* = 6.4 Hz, 2H), 5.51 (s, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 160.2(C), 150.5(C), 143.6(CH), 139.4(C), 137.0(C), 131.7(CH), 128.8(CH), 128.5(2CH), 127.4(CH), 126.8(2CH), 125.5(C), 123.6(C), 122.7(CH), 122.4(CH), 121.9(CH), 119.3(CH), 118.7(C), 115.3(CH), 111.0(CH), 107.4(C), 47.7(CH_2). HR-MS(ESI):m/z calcd for $C_{23}H_{18}N_3O$ $[M+H]^+$ 352.1450; found 352.1446

3-(1*H*-benzo[d]imidazol-2-yl)quinolin-2(1*H*)-one 3g:

Reaction time: 24h, reaction temperature = 150°C, 0.85 mmol scale: 50 mg, 23% yield after column chromatography (CH_2Cl_2/EtOAc 90/10). R_f = 0.26 (CH_2Cl_2/EtOAc 8/2); light yellow solid; m.p.= 323-324°C; IR (neat): 3358, 3033, 2887, 1652, 1615, 1565, 1521, 1404, 1316, 1212, 1166, 1026, 1006 cm^{-1}. ^{1}H NMR (300 MHz, DMSO) δ (ppm) 12.85 (s, 1H), 12.47 (s,

1H), 9.12 (s, 1H), 7.95 (d, *J* = 7.0 Hz, 1H), 7.70 (dd, *J* = 6.0, 3.2 Hz, 2H), 7.63 (ddd, *J* = 8.4, 7.2, 1.4 Hz, 1H), 7.45 (d, *J* = 8.3 Hz, 1H), (t, *J* = 8.0 Hz, 1H), 7.22 (dd, *J* = 6.0, 3.1 Hz, 2H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 160.7(C), 147.5(C), 139.3(CH), 138.7(3C), 131.7(CH), 129.0(CH), 122.7(CH), 122.3(2CH), 119.6(C), 119.1(C), 115.3(3CH). HR-MS(ESI):m/z calcd for $C_{16}H_{12}N_3O$ $[M+H]^+$ 262.0980; found 262.0978.

1-methyl-3-(1-methyl-1*H*-naphtho[2,3-d]imidazol-2-yl)quinolin-2(1*H*)-one 3h:
Reaction time: 12h, 0.55 mmol scale: 170 mg, 74% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.26 (CH_2Cl_2/MeOH 98/2); white solid recrystallized from acetone; m.p.= 246-248°C; IR (neat): 3046, 2947, 1648, 1596, 1572, 1511, 1470, 1452, 1397, 1308, 1264, 1244, 1065 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.39 (s, 1H), 8.29 (s, 1H), 8.22 – 7.88 (m, 2H), 7.81 (s, 1H), 7.69 (t, *J* = 9.4 Hz, 2H), 7.60 – 7.13 (m, 4H), 3.89 (s, 3H), 3.84 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.2(C), 154.8(C), 143.3(CH), 143.2(C), 140.9(C), 137.5(C), 132.2(CH), 130.8(C), 130.4(C), 130.0(CH), 128.7(CH), 127.7(CH), 124.4(CH), 123.5(CH), 123.2(C), 122.9(CH), 120.1(C), 116.8(CH), 114.4(CH), 105.4(CH), 32.0(CH_3), 30.1(CH_3). HR-MS(ESI):m/z calcd for $C_{22}H_{18}N_3O$ $[M+H]^+$ 340.1450; found 340.1450.

6-methoxy-3-(1-(4-methoxybenzyl)-5,6-dimethyl-1*H*-benzo[d]imidazol-2-yl)-1-methylquinolin-2(1*H*)-one 3i:
Reaction time: 12h, 0.38 mmol scale: 150 mg, 88% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.09 (Cyclohexane/EtOAc, 5/5); white solid recrystallized from diisopropyl ether-MTBE (5/5); m.p.= 183-185°C; IR (neat): 2936, 1648, 1624, 1575, 1513, 1463, 1429, 1244, 1177, 1070, 1033 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.17 (s, 1H), 7.60 (s, 1H), 7.34 (d, *J* = 9.2 Hz, 1H), 7.30 – 7.11 (m, 1H), 7.03 (dd, *J* = 17.0, 9.4 Hz, 2H), 6.96 (d, *J* = 8.7 Hz, 2H), 6.71 (d, *J* = 8.7 Hz, 2H), 5.42 (s, 2H), 3.86 (s, 3H), 3.79 (s, 3H), 3.69 (s, 3H), 2.37 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 159.9(C), 159.1(C), 155.2(C), 149.4(C), 142.6(CH), 135.4(C), 134.4(C), 132.8(C), 131.8(C), 128.9(C), 128.2(CH), 125.3(C), 123.6(C), 121.2(CH), 120.8(C), 119.6(CH), 115.7(CH), 114.2(CH), 111.1(CH), 55.9(CH_3), 55.4(CH_3), 48.5(CH_2), 30.3(CH_3), 20.8(CH_3), 20.4(CH_3). HR-MS(ESI):m/z calcd for $C_{28}H_{28}N_3O_3$ $[M+H]^+$ 454.2131; found 454.2128

3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)-6-methoxy-1-methylquinolin-2(1*H*)-one 3j:
Reaction time: 20h, 0.48 mmol scale: 145 mg, 77% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.17 (Cyclohexane/EtOAc 5/5); light yellow solid recrystallized from diisopropyl ether-MeOH (95/5); m.p.= 156-157°C; IR (neat): 3052, 2936, 2837, 1647, 1623, 1575, 1511, 1455, 1239, 1162, 1075, 1032 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.19 (s, 1H), 7.85 (d, *J* = 7.7 Hz, 1H), 7.40 – 7.11 (m, 8H), 7.08 – 6.98 (m, 3H), 5.53 (s, 2H), 3.85 (s, 3H), 3.79 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 159.9(C), 155.1(C), 150.5(C), 142.8(CH), 142.6(C), 136.6(C), 135.9(C), 135.4(C), 128.8(2CH), 127.7(CH), 126.9(2CH), 123.5(C), 123.4(CH), 122.7(CH), 121.3(CH), 120.7(C), 119.8(CH), 116.4(CH), 115.8(CH), 111.0(CH), 55.9(CH_3), 49.1(CH_2), 30.3(CH_3). HR-MS(ESI):m/z calcd for $C_{25}H_{22}N_3O_2$ $[M+H]^+$ 396.1712; found 396.1716.

3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)-6-bromo-1-methylquinolin-2(1*H*)-one 3k:
Reaction time: 24h, 0.24 mmol scale: 62 mg, 58% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.45 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone-MTBE (95/5); m.p.= 201-202°C;IR (neat): 2923, 1641, 1584, 1565, 1457, 1204, 1089 cm^{-1}. ^{1}H NMR (300 MHz, DMSO) δ (ppm) 8.37 (s, 1H), 8.12 (d, *J* = 2.2 Hz, 1H), 7.86 (dd, *J* = 9.1, 2.3 Hz, 1H), 7.77 – 7.66 (m, 1H), 7.60 (d, *J* = 9.1 Hz, 1H), 7.49 – 7.38 (m, 1H), 7.2 1 (dt, *J* = 16.0, 6.4 Hz, 5H), 7.04 (d, *J* = 6.3 Hz, 2H), 5.46 (s, 2H), 3.72 (s, *J* = 15.4 Hz, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 159.5(C), 150.0(C), 142.8(C), 141.4(CH), 139.3(C), 136.9(C), 135.5(C), 134.3(CH), 131.3(CH), 128.5(2CH), 127.4(CH), 126.9(2CH), 124.1(C), 122.8(CH), 122.0(CH), 121.1(C), 119.3(CH), 117.4(CH), 114.4(C), 111.1(CH), 47.8(CH_2), 30.1(CH_3). HR-MS(ESI):m/z calcd for $C_{24}H_{19}BrN_3O$ $[M+H]^+$ 444.0711; found 444.0712.

6-chloro-1-methyl-3-(1-methyl-1*H*-benzo[d]imidazol-2-yl)-4-phenylquinolin-2(1*H*)-one 3l:
Reaction time: 12h, 0.38 mmol scale: 120 mg, 79% yield after column chromatography (CH_2Cl_2/MeOH 99.75/0.25). R_f = 0.13 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone; m.p.= 212-214°C; IR (neat): 1647, 1564, 1464, 1422, 1391, 1310, 1239, 1067 cm^{-1}.^{1}H NMR (300 MHz, $CDCl_3$) δ (ppm) 7.71 – 7.55 (m, 2H), 7.49 (d, *J* = 7.3 Hz, 1H), 7.43 (d, *J* = 9.0 Hz, 1H), 7.37 – 7.12 (m, 7H), 7.04 (d, *J* = 4.3 Hz, 1H), 3.82 (s, 3H), 3.57 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.4(C), 152.2(C), 148.4(C), 143.0(C), 139.2(C), 135.2(C), 134.1(CH), 132.0(CH), 130.1(CH), 128.9(CH), 128.9(CH), 128.2(2CH), 127.6(CH), 127.0(C), 123.3(C), 122.6(CH), 121.9(C), 121.9(CH), 120.1(CH), 116.0(CH), 109.4(CH), 30.6(CH_3), 30.4(CH_3). HR-MS(ESI):m/z calcd for $C_{24}H_{19}ClN_3O$ $[M+H]^+$ 400.1217; found 400.1213.

3-(1-benzyl-1H-benzo[d]imidazol-2-yl)-5-bromo-1-methylpyridin-2(1*H*)-one 3m:
Reaction time: 12h, 0.36 mmol scale: 105 mg, 74% yield after column chromatography (CH_2Cl_2/MeOH 99.75/0.25). R_f = 0.13 (Cyclohexane/EtOAc 5/5); yellow solid recrystallized from acetone-MTBE (95/5); m.p.= 211-213°C; IR (neat): 1651, 1587, 1557, 1455, 1408, 1296, 1251 cm^{-1}. ^{1}H NMR (300 MHz, DMSO) δ (ppm) 8.32 (d, *J* = 2.8 Hz, 1H), 7.89 (d, *J* = 2.8 Hz, 1H), 7.70 – 7.63 (m, 1H), 7.48 – 7.35 (m, 1H), 7.31 – 7.12 (m, 5H), 7.03 (dd, *J* = 7.7, 1.6 Hz, 2H), 5.43 (s, 2H), 3.54 (s, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 158.9(C), 149.7(C), 145.0(CH), 142.9(C), 142.4(CH), 137.0(CH), 135.5(CH), 128.5(2CH), 127.4(CH), 126.9(2CH), 122.7(CH), 122.4(C), 121.9(CH), 119.3(CH), 111.0(CH), 95.6(C), 47.7(CH_2), 37.7(CH_3). HR-MS(ESI):m/z calcd for $C_{20}H_{17}BrN_3O$ $[M+H]^+$ 394.0555; found 394.0554.

3-(1-benzyl-1*H*-benzo[d]imidazol-2-yl)-2*H*-chromen-2-one 3n:

Reaction time: 24h, 0.36 mmol scale: 120 mg, 95% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). R_f = 0.40 (Cyclohexane/EtOAc 5/5); light yellow solid recrystallized from diisopropyl ether; m.p.= 185-186°C; IR (neat): 3062, 1720, 1608, 1497, 1455, 1399, 1350, 1229, 1169, 1154, 1030, 1018 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.11 (s, 1H), 7.77 (d, *J* = 6.3 Hz, 1H), 7.52 (t, *J* = 7.2 Hz, 1H), 7.45 (d, *J* = 7.7 Hz, 1H), 7.31 (d, *J* = 8.3 Hz, 1H), 7.27 – 7.04 (m, 7H), 6.96 (d, *J* = 7.6 Hz, 2H), 5.43 (s, 2H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 159.4(C), 154.5(C), 146.9(CH), 143.2(C), 140.6(C), 136.2(C), 133.2(CH), 128.9(3CH), 128.0(CH), 126.9(2CH), 125.1(CH), 124.7(C), 123.8(CH), 122.9(CH), 120.3(CH), 119.7(C), 118.7(C), 116.9(CH), 110.9(CH), 48.9(CH_2). HR-MS(ESI):m/z calcd for $C_{23}H_{17}N_2O_2$ $[M+H]^+$ 353.1290; found 353.1291.

7-(benzyloxy)-8-methyl-3-(1-methyl-1*H*-benzo[d]imidazol-2-yl)-4-phenyl-2*H*-chromen-2-one 3o:

Reaction time: 24h, 0.57 mmol scale: 208 mg, 78% yield after column chromatography (Cyclohexane/EtOAc 75/25). R_f = 0.18 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone; m.p.= 269-270°C; IR (neat): 3062, 3033, 2928, 1718, 1600, 1288, 1110, 1005 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 7.66 (dd, *J* = 6.4, 1.6 Hz, 1H), 7.55 – 7.15 (m, 12H), 7.11 (d, *J* = 8.9 Hz, 1H), 7.02 (s, 1H), 6.84 (d, *J* = 9.0 Hz, 1H), 5.20 (s, 2H), 3.60 (s, 3H), 2.47 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.6(C), 160.3(C), 158.2(C), 153.4(C), 147.3(C), 142.9(C), 136.3(C), 135.2(C), 133.7(C), 129.8(CH), 129.2(CH), 128.9(2CH), 128.7(CH), 128.4(CH), 128.2(CH), 127.4(CH), 127.2(2CH), 126.9(CH), 122.8(CH), 122.1(CH), 120.1(CH), 115.0(C), 113.6(C), 113.4(C), 109.5(CH), 108.7(CH), 70.7(CH_2), 30.6(CH_3), 8.7(CH_3). HR-MS(ESI):m/z calcd for $C_{31}H_{25}N_2O_3$ $[M+H]^+$ 473.1865; found 473.1662.

Analytical Data for 3-heteroarylquinolin-2(1*H*)-ones 4

3-(benzo[d]thiazol-2-yl)-1-methylquinolin-2(1*H*)-one 4a:

Reaction time: 1h30, 0.44 mmol scale: 110 mg, 85% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). R_f = 0.61 (Cyclohexane/EtOAc 5/5); light yellow solid; m.p.= 253-254°C; IR (neat): 3056, 2928, 1634, 1584, 1566, 1455, 1194, 952 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 9.12 (s, 1H), 8.10 (d, *J* = 8.1 Hz, 1H), 7.99 (ddd, *J* = 7.9, 1.2, 0.6 Hz, 1H), 7.83 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.71 – 7.63 (m, 1H), 7.55 – 7.48 (m, 1H), 7.47 – 7.37 (m, 2H), 7.37 – 7.30 (m, 1H), 3.89 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 161.9(C), 160.7(C), 152.3(C), 140.2(C), 138.0(CH), 137.1(C), 132.3(CH), 130.6(CH), 126.3(CH), 125.0(CH), 124.9(CH), 123.7(C), 123.4(CH), 123.2(CH), 122.8(CH), 121.8(CH), 121.4(CH), 120.3(C), 114.4(CH), 30.2(CH_3). HR-MS(ESI):m/z calcd for $C_{17}H_{13}N_2OS$ $[M+H]^+$ 293.0749; found 293.0750.

3-(benzo[d]thiazol-2-yl)-6-bromo-1-methylquinolin-2(1*H*)-one 4b:

Reaction time: 11h, 0.37 mmol scale: 108 mg, 79% yield after column chromatography (CH_2Cl_2). R_f = 0.53 (Cyclohexane/EtOAc 5/5); yellow solid recrystallized from acetone; m.p.= 275-276°C; IR (neat): 2925, 1637, 1581, 1318, 1222, 1198 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 9.08 (s, 1H), 8.12 (d, *J* = 8.0 Hz, 1H), 8.00 (d, *J* = 8.0 Hz, 1H), 7.95 (d, *J* = 2.3 Hz, 1H), 7.74 (dd, *J* = 9.0, 2.3 Hz, 1H), 7.58 – 7.50 (m, 1H), 7.46 – 7.39 (m, 1H), 7.33 (d, *J* = 9.0 Hz, 1H), 3.87 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.5(C), 152.2(C), 148.1(C), 139.0(C), 137.2(C), 136.5(CH), 134.9(CH), 132.4(CH), 126.4(CH), 125.3(CH), 124.7(C), 122.9(CH), 121.9(CH), 121.7(C), 116.2(CH), 116.0(CH), 30.4(CH_3). HR-MS(ESI):m/z calcd for $C_{17}H_{12}BrN_2OS$ $[M+H]^+$ 370.9854; found 370.9850.

3-(benzo[d]oxazol-2-yl)-1-methylquinolin-2(1*H*)-one 4c:

Reaction time: 1h30, 0.50 mmol scale: 110 mg, 80% yield after column chromatography (CH_2Cl_2/MeOH 99.5/0.5). Rf = 0.21 (Cyclohexane/EtOAc 5/5); light yellow solid recrystallized from MTBE; m.p.= 161-162°C; IR (neat): 2975, 1659, 1618, 1572, 1453, 1249, 1221, 1066 cm^{-1}. ^1H NMR (300 MHz, DMSO) δ (ppm) 8.87 (s, 1H), 7.98 (d, *J* = 6.8 Hz, 1H), 7.88 – 7.72 (m, 3H), 7.61 (d, *J* = 8.5 Hz, 1H), 7.50 – 7.39 (m, 2H), 7.36 (t, *J* = 7.3 Hz, 1H), 3.73 (s, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 157.8(C), 142.4(CH), 141.1(C), 140.6(C), 136.7(C), 133.0(CH), 130.4(CH), 125.7(CH), 124.8(CH), 122.6(CH), 119.8(CH), 119.8(C), 118.9(C), 118.1(C), 114.9(CH), 110.9(CH), 29.7(CH_3). HR-MS(ESI):m/z calcd for $C_{17}H_{13}N_2O_2$ $[M+H]^+$ 277.0977; found 277.0978.

3-(benzo[d]oxazol-2-yl)-6-bromo-1-methylquinolin-2(1*H*)-one 4d:

Reaction time: 1h30, 0.42 mmol scale: 135 mg, 91% yield after column chromatography (CH_2Cl_2). Rf = 0.18 (Cyclohexane/EtOAc 5/5); yellow solid recrystallized from acetone; m.p.= 280-281°C; IR (neat): 3085, 1662, 1564, 1491, 1452, 1419, 1250, 1212, 1087, 1062 cm^{-1}.^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.65 (s, 1H), 7.95 – 7.58 (m, 4H), 7.44 – 7.34 (m, 2H), 7.30 (d, *J* = 9.0 Hz, 1H), 3.82 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 159.7(C), 158.5(C), 150.7(C), 141.9(C), 140.3(CH), 139.9(C), 135.4(CH), 132.1(CH), 125.9(CH), 124.9(CH), 121.0(C), 120.8(CH), 120.2(C), 116.2(CH), 115.6(C), 111.0(CH), 30.2(CH_3). HR-MS(ESI):m/z calcd for $C_{17}H_{12}BrN_2O_2$ $[M+H]^+$ 355.0082; found 355.0078

1-methyl-3-(5-methylbenzo[d]oxazol-2-yl)quinolin-2(1*H*)-one 4e:

Reaction time: 2h30, 0.38 mmol scale: 86 mg, 79% yield after column chromatography (CH_2Cl_2/MeOH 99/1). R_f = 0.39 (Cyclohexane/EtOAc 5/5); light yellow solid recrystallized from acetone; m.p.= 164-165°C; IR (neat): 3052, 2925, 1658, 1613, 1593, 1572, 1455, 1264, 1221, 1192, 1065 cm^{-1}. ^1H NMR (300 MHz, DMSO) δ (ppm) 8.85 (s, 1H), 7.97 (d, *J* = 6.8 Hz, 1H), 7.70 (m, 4H), 7.35 (t, *J* = 7.3 Hz, 1H), 7.25 (d, *J* = 8.3 Hz, 1H), 3.73 (s, 3H), 2.45 (s, 3H). ^{13}C NMR (75 MHz, DMSO) δ (ppm) 154.1(C), 145.2(C), 142.1(CH), 140.7(C), 134.1(C), 132.9(CH), 130.3(CH), 126.7(CH), 125.0(C), 122.8(C), 122.5(CH),

119.6(CH), 118.9(C), 118.1(C), 114.9(CH), 110.3(CH), 29.7(CH_3), 21.0(CH_3). HR-MS(ESI):m/z calcd for $C_{18}H_{15}N_2O_2$ $[M+H]^+$ 291.1134; found 291.1135.

1-benzyl-3-(4-methylthiazol-2-yl)quinolin-2(1*H*)-one 4f:
Reaction time: 2h, 0.35 mmol scale: 85 mg, 72% yield after column chromatography (CH_2Cl_2). R_f = 0.29 (Cyclohexane/EtOAc 75/25); orange solid recrystallized from acetone; m.p.= 171-172°C; IR (neat): 3035, 2920, 1640, 1588, 1565, 1515, 1496, 1310, 1236, 1050 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 9.02 (s, 1H), 7.81 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.51 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.41 – 7.19 (m, 7H), 7.10 (s, 1H), 5.73 (s, 2H), 2.60 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.7(C), 160.1(C), 152.5(C), 139.1(C), 136.0(C), 136.0(CH), 131.5(CH), 130.3(CH), 129.0(2CH), 127.6(CH), 126.7(2CH), 123.6(C), 123.1(CH), 120.7(C), 117.3(CH), 115.2(CH), 46.7(CH_2), 17.4(CH_3). HR-MS(ESI):m/z calcd for $C_{20}H_{17}N_2OS$ $[M+H]^+$ 333.1062; found 333.1060.

3-(9-benzyl-6-(methylthio)-9H-purin-8-yl)-1-methylquinolin-2(1*H*)-one 4g:
Reaction time: 13h, 0.29 mmol scale: 70 mg, 72% yield after column chromatography (CH_2Cl_2/MeOH 99.75/0.25). R_f = 0.55 (Cyclohexane/EtOAc 5/5); white solid recrystallized from acetone; m.p.= 220-221°C; IR (neat): 3030, 2927, 1649, 1642, 1597, 1578, 1564, 1498, 1333, 1250, 1183, 1071, 1015 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.79 (s, 1H), 8.04 (s, 1H), 7.65 (ddd, *J* = 8.7, 7.2, 1.5 Hz, 1H), 7.55 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.41 (d, *J* = 8.5 Hz, 1H), 7.32 – 7.21 (m, 1H), 7.08 (dd, *J* = 5.2, 1.9 Hz, 3H), 6.96 (dd, *J* = 7.0, 2.6 Hz, 2H), 5.67 (s, 2H), 3.82 (s, 3H), 2.75 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 161.0(C), 160.1(C), 152.2(CH), 150.5(C), 150.2(C), 143.4(CH), 140.7(C), 136.4(C), 132.4(CH), 131.3(C), 130.1(CH), 128.6(2CH), 127.8(CH), 127.5(2CH), 123.0(C), 122.9(CH), 119.8(C), 114.4(CH), 47.4(CH_2), 30.2(CH_3), 12.0(CH_3). HR-MS(ESI):m/z calcd for $C_{23}H_{20}N_5OS$ $[M+H]^+$ 414.1389; found 414.1389.

3-(benzo[b]thiophen-2-yl)-1-methylquinolin-2(1*H*)-one 4h:
Reaction time: 24h, 0.37 mmol scale of quinolinone and 2 equiv of benzothiophene: 44 mg, 41% yield after column chromatography (Cyclohexane/EtOAc 80/20). R_f = 0.39 (Cyclohexane/EtOAc 75/25); yellow solid recrystallized from acetone; m.p.= 184-186°C; IR (neat): 3049, 1634, 1589, 1566, 1460, 1313, 1235, 1168, 1103, 1040 cm^{-1}. ^1H NMR (300 MHz, $CDCl_3$) δ (ppm) 8.18 (s, 1H), 8.17 (s, 1H), 7.89 – 7.77 (m, 2H), 7.65 (dd, *J* = 7.8, 1.3 Hz, 1H), 7.58 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.41 – 7.24 (m, 4H), 3.83 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ (ppm) 160.5(C), 140.6(C), 139.9(C), 139.2(C), 138.3(C), 134.7(CH), 130.8(CH), 129.2(CH), 125.3(C), 124.8(CH), 124.4(CH), 123.9(CH), 123.4(CH), 122.7(CH), 122.1(CH), 120.5(C), 114.2(CH), 30.2(CH_3). HR-MS(ESI):m/z calcd for $C_{36}H_{26}N_2NaO_2S_2$ $[2M+Na]^+$ 605.1333; found 605.1336.

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