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Copper(I)-Y Zeolite-Catalyzed Regio- and Stereoselective [2 + 2 + 2] Cyclotrimerization Cascade: An Atom- and Step-Economical Synthesis of Pyrimido[1,6-*a*]quinoline

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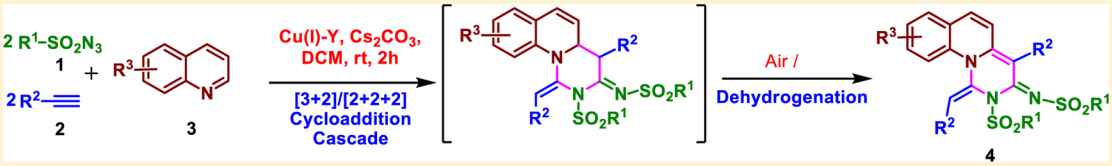
Supporting Information



ABSTRACT: An elegant copper(I)-Y zeolite-catalyzed tandem process, involving ketenimine-based termolecular [2 + 2 + 2]/[NC + CC + NC] cycloaddition, using sulfonyl azide, alkyne, and quinoline, to prepare pyrimido[1,6-*a*]quinolines is reported. In this straightforward, highly atom- and step-economical protocol, copper(I) promotes for azide−alkyne [3 + 2] cycloaddition which is followed by ring-rearrangement/ketenimine formation/regio- and stereoselective [2 + 2 + 2] termolecular cycloaddition and dehydrogenation cascade to yield selectively the *E*-isomer of pyrimido[1,6-*a*]quinoline.

INTRODUCTION

Transition-metal-mediated cascade reactions constitute a fascinating branch of organic chemistry and has been the subject of intense research in recent years. The benefits of cascade reactions are the combination of multiple reactions in single operations, atom economy, as well as economies of time, labor, and resource managements.[1] A pre-eminent goal of developing a cascade catalyst system is to produce targeted structural complexity, and the synthetic efficiency of the catalytic system is evaluated by the number and diversity of individual transformations involved and the number of new bonds that can be formed by using the catalyst, as these factors are usually proportional to the complexity of the final products.[2]

Cycloaddition reactions such as [2 + 2 + 2], also called as cyclotrimerization, are the most demanding classes of reactions in organic chemistry as it is a method for construction of new bonds in single processes.[3] In principle, though thermal [2 + 2 + 2] cycloadditions are symmetry-allowed, they are not common and are not favored due to the decrease in entropy associated with bringing three reactants together.[4,5] However, this problem can be overcome by employing transition-metal catalysts as sites of stepwise addition processes. Consequently, transition-metal (Co, Fe, Rh, Ru, Ni, Pd, Nb, Cr, Zr, Ir., etc.)-catalyzed [2 + 2 + 2] cycloadditions are employed as powerful and reliable tools for the rapid construction of poly substituted six-membered carbo- and heterocycles with high molecular complexity by utilizing simple unsaturated substrates.[6] Although various types of transition-metal catalysts and substrates have been investigated for inter- and intramolecular reactions, copper-catalyzed [2 + 2 + 2] inter- and intramolecular cycloadditions remain a challenge. While cascade processes involving single cycloaddition steps are very common, those engaging two or more cycloaddition reactions are very rare, especially when transition metals are involved.[7] Developing novel cascade reactions combining two cycloaddition steps in one sequence without isolating the intermediates and the formation of multiple C−C and C−heteroatom bonds in aromatic rings are desirable for construction of complex molecular architectures.[8]

Herein, we report, for the first time, an unprecedented copper(I)-Y zeolite-catalyzed tandem process involving *N*-sulfonylketenimine-based [2 + 2 + 2]/[NC + CC + NC] cyclotrimerization reaction with involvement of two C−N bonds, to prepare highly functionalized pyrimido[1,6-*a*]-quinolines from sulfonyl azide, alkyne, and quinoline (Scheme 1). To the best of our knowledge, there are no reports on *N*-sulfonylketenimine-based termolecular [2 + 2 + 2] cycloaddition reactions.

Quinoline-based nitrogen-containing heterocycles possess diverse biological and pharmacological properties such as anticancer, antimycobacterial, anticonvulsant, antibacterial, antimalarial, and cardiovascular activities, HIV-1 integrase inhibitors, antiprotozoic drugs, and antineoplastic activity.[9] Ketenimine-mediated tandem reactions have gained wide interest for the construction of complex organic compounds, particularly heterocyclic compounds of different ring sizes, because of their high efficiency, diverse reactivity, bond-forming ability and selectivity.[10] Generally, it involves nucleophilic and radical addition to electrophilic carbon atoms and pericyclic reactions such as [2 + 2, 3 + 2, 4 + 2] cycloadditions,

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Scheme 1. Copper(I)-Y-Catalyzed Regio- and Stereoselective [2 + 2 + 2] Cyclotrimerization Reaction

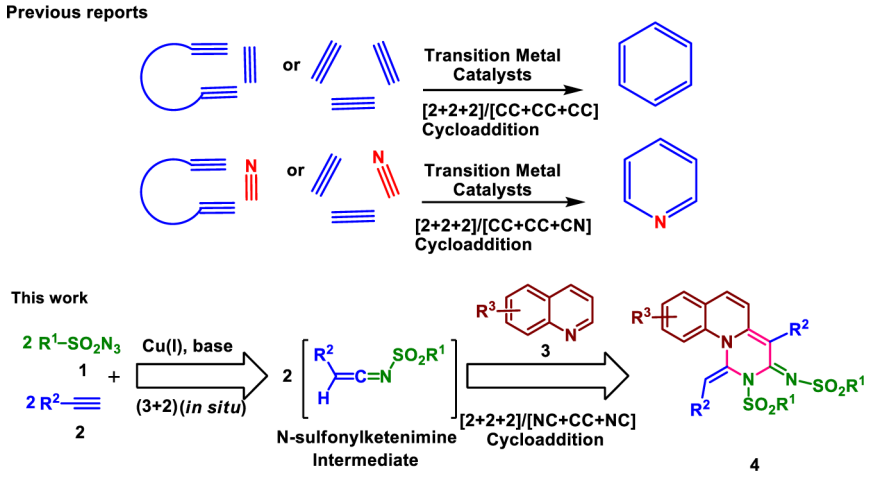
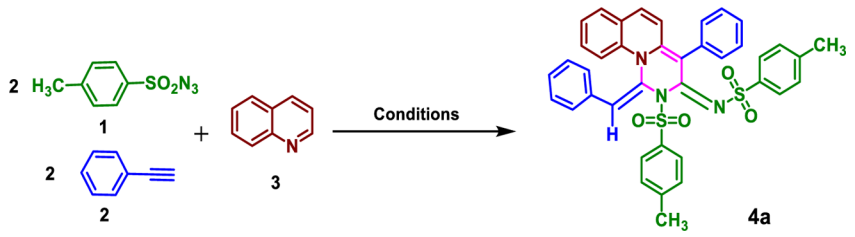


Table 1. Optimization of Reaction Conditions in the Multicomponent Reaction of Quinoline, Phenylacetylene and *p*-Toluenesulfonyl Azide[a]



entry	catalyst	solvent	base	yield of **4** (%)[b]
1[c]	CuI	CH_2Cl_2	Et_3N	27
2	CuI	CH_2Cl_2	Et_3N	48
3	CuBr	CH_2Cl_2	Et_3N	56
4	CuBr	CH_2Cl_2	DIPEA	–
5	CuBr	CH_2Cl_2	Cs_2CO_3	51
6	CuCl	CH_2Cl_2	Et_3N	30
7	Cu-Al-HT	CH_2Cl_2	Et_3N	-
8	Cu^I-Y	CH_2Cl_2	Et_3N	64
9	Cu(I)-Y	CH_3CN	Et_3N	53
10	Cu(I)-Y	toluene	Et_3N	32
11	Cu(I)-Y	1,4-dioxane	Et_3N	–
12	Cu(I)-Y	DCE	Et_3N	trace
13	Cu(I)-Y	DMSO	Et_3N	trace
14	Cu(I)-Y	CH_2Cl_2	Cs_2CO_3	68
15	Cu(I)-Y	CH_2Cl_2	K_2CO_3	42
16	Cu(I)-Y	CH_2Cl_2	DIPEA	36
17[d]	Cu(I)-Y	CH_2Cl_2	Cs_2CO_3	71
18[e]	Cu(I)-Y	CH_3CN	Cs_2CO_3	trace
19[f]	CuI	CH_2Cl_2	–	18
20[g]	–	CH_2Cl_2	Et_3N	–
21[h]	CuI	CH_2Cl_2	Et_3N	–

[a]Phenylacetylene (1.0 mmol), tosyl azide (1.0 mmol), quinoline (0.6 mmol), base (1.2 mmol), catalyst (10 mol %), solvent (3.0 mL), rt, open air, 2 h. [b]Yield. [c]N_2 atmosphere. [d]Reaction up to 6 h. [e]Reaction at 50 °C. [f]Without base. [g]Without catalyst. [h]Without sulfonyl azides.

sigmatropic rearrangements, and 6π-electrocyclic ring closure reactions.[11−14]

RESULTS AND DISCUSSION

To start with, tosyl azide (**1a**), phenylacetylene (**2a**), and quinoline (**3a**) were used as model substrates for optimizing the reaction conditions, and the observed results are summarized in Table 1. When CuI salt was employed as the catalyst, dichloromethane (DCM) as the solvent, triethylamine (TEA) as base under nitrogen atmosphere for 2 h, **4** was obtained in 27% yield. The molecular structure of **4** was unambiguously established by X-ray crystallography (see Supporting Information, Figure S1). The reaction also proceeded well in air, and the product yield had increased to 48%. In the absence of copper sources and sulfonyl azides no formation of **4** was observed. Among the various homogeneous

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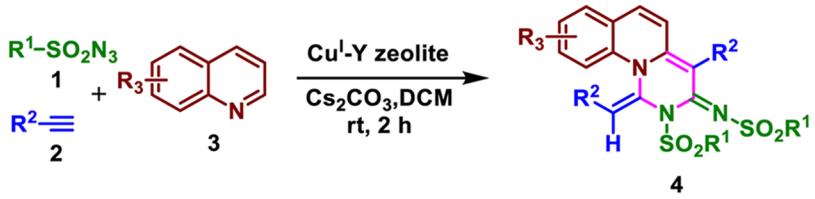
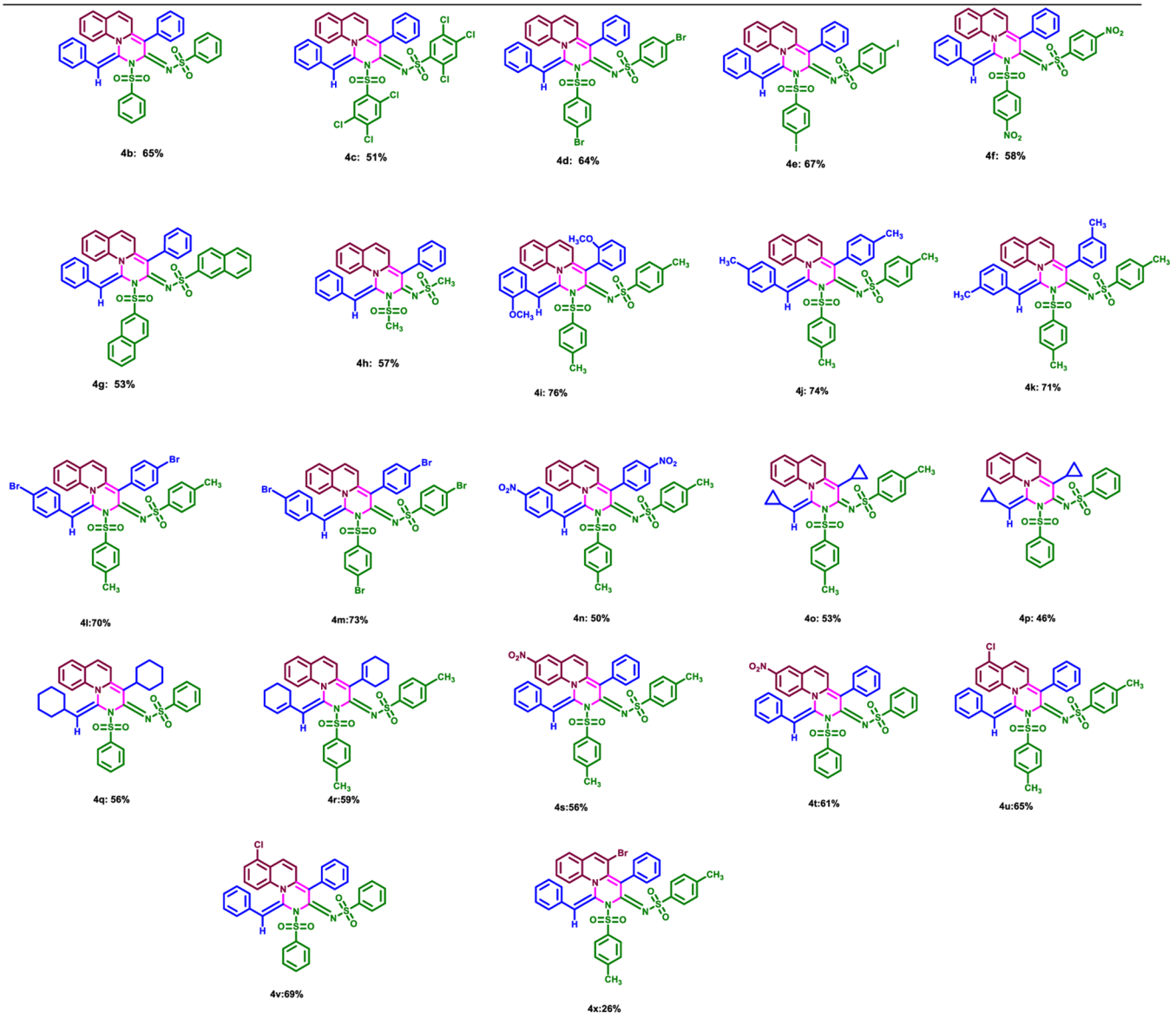
Table 2. Cyclotrimerization Reaction with Various Sulfonyl Azides, Terminal Alkynes, and Quinolines[a]





[a]Reaction conditions:Alkyne (1.0 mmol), sulfonyl azide (1.0 mmol), quinolines (0.6 mmol), Cs_2CO_3 (390 mg, 1.2 mmol), Cu^I-Y zeolite (20 mg, 10 mol %), DCM (3.0 mL), rt, open air, 2 h. [b]Yield.

copper sources studied, CuBr gave better yields (56%) than CuCl (30%) and CuI (48%) (Table 1, entries 2−6), indicating that the nature of the catalyst also played a prominent role.

Our ongoing efforts[15] to explore the scope of metal-exchanged zeolites as catalysts for organic syntheses prompted us to probe the Cu(I)-Y zeolite catalyst for this cascade reaction.[16,17] Cu(I)-exchanged Y-zeolite was prepared by following the literature procedure[18] and characterized by powder X-ray diffraction pattern (PXRD), energy dispersive X-ray spectrum (EDX), and ultra violet-diffuse reflectance spectroscopy (UV-DRS) (see Supporting Information, Figures S2−S4). When carried out with Cu(I)-Y zeolite, the cyclotrimerization reaction proceeded readily and afforded 64% yield of **4** (Table 1, entry 8).The reaction, however, failed when other heterogeneous copper catalysts like Cu-Al-HT were employed (Table 1, entry 7). Remarkably, catalytic amount of Cu(I)-Y (10 mol %) was sufficient to form **4** in high yield. The formation of **4** was largely dependent on the solvent, and DCM was found to be the best choice (Table 1, entries 9−13). In the absence of base, the reaction furnished **4** in only 18% yield. Among the different bases, Cs_2CO_3 gave better yield than TEA, *N*,*N*-diisopropylethylamine (DIPEA), and K_2CO_3 (Table 1,

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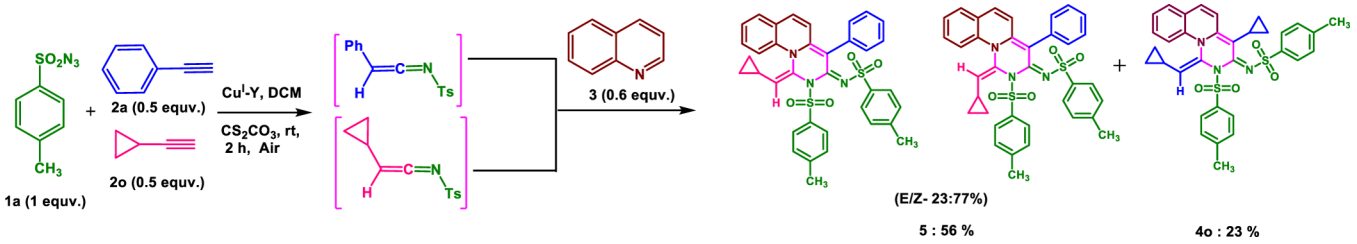
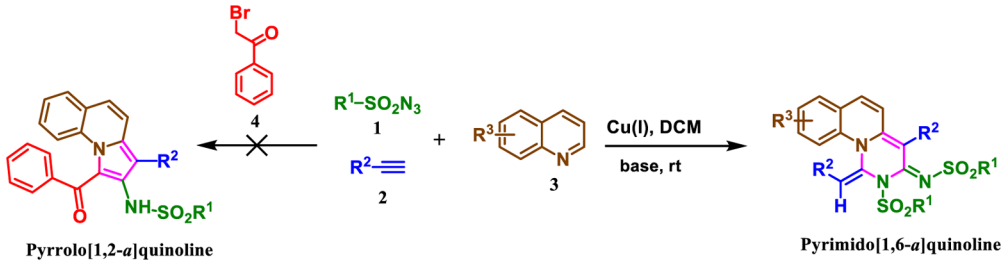
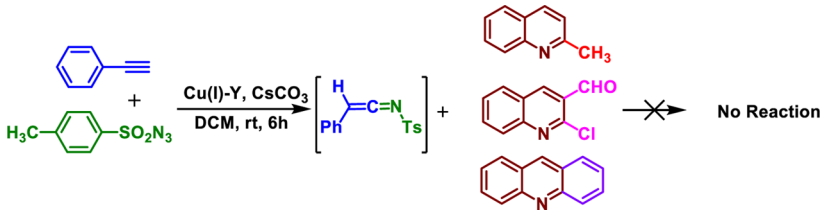
Scheme 2. Competitive Reaction between Two Different *N*-Sulfonylketenimines with Quinoline



Scheme 3. Competition between Copper(I)-Catalyzed Three and Four Component Reactions



Scheme 4. Control Experiments in Copper(I)-Y Zeolite-Catalyzed [2 + 2 + 2] Cyclotrimerization



entries 14−16). Prolonging the reaction time up to 6 h failed to show significant changes in product yield (71%) (Table 1, entry 17). It was also found that the catalytic reaction was most efficient at room temperature. However, when the reaction temperature was raised to 50 °C, the reaction was completely suppressed (Table 1, entry 18). Thus, the optimized reaction conditions are Cu(I)-Y zeolite as catalyst, DCM as solvent, Cs_2CO_3 as base, under air at room temperature for 2 h.

To explore the scope of the optimized catalytic system, the effect of substitutions at various sulfonyl azides, alkynes, and quinolines (Table 2) were also studied. Electron-rich and halogen-substituted sulfonyl azides (Table 2, entries **4a**−**4e**) gave better yields than electron-deficient, fused ring, and aliphatic sulfonyl azides (Table 2, entries **4i**−**4h**). Similarly various substituents on terminal alkyne were also tolerated and yielded the desired product. Among various alkynes studied such as electron-rich (Table 2, **4i** and **4k**), halogen-substituted (Table 2, **4l** and **4m**), electron-deficient (Table 2, **4n**) and nonaromatic alkynes (Table 2, **4o**−**4r**), electron-rich alkynes gave better yields than other alkyne systems. The 5-chloro- and 6-nitro-substituted quinolines were also employed, in which moderate yields were observed (Table 2, entries **4s**−**4v**), and when the sterically more-demanding 3-bromoquinoline was employed, the yield of the product decreased significantly (Table 2, entry **4x**). It is interesting to note that our catalytic reaction affords exclusively *E*- isomer in all the cases. The reactivity of pyridine was also studied under the present reaction conditions: the reaction is very slow, and only trace amount of the product was obtained (<1).

We are also performed the reaction with different alkynes under the optimal conditions. In one reaction, phenylacetylene and 4-methylphenylacetylene are used. Only phenylacetylene-substituted product (**4a**) is observed exclusively. In another reaction, phenylacetylene and cyclopropylacetylene are used, and in this case two products are formed. In one (**4o**), only cyclopropylacetylene is incorporated in the final product (formed in 23% yield). Another product (**5**) is also obtained in 56% yield (Scheme 2) as mixture of two different structural isomers (*E*:*Z* = 23:77%). The products and their ratio were confirmed from NMR and HRMS-ESI analyses.

A control experiment involving Cu(I)-Y-catalyzed four component reaction of sulfonyl azide, alkyne, quinoline, and 2-bromoacetophenone is also carried out. We anticipate that quinoline will react with 2-bromoacetophenone to generate the carbanion, and nucleophilic attack by the carbanion on the central carbon of *N*-sulfonylketenimine with subsequent cyclization/dehydrogenation will form pyrrolo[1,2-*a*]quinoline. However, this is not observed, and on the other hand, quinoline reacts chemoselectively with two molecules of *N*-sulfonylketenimine to form pyrimido[1,6-*a*]quinoline in a three component [2 + 2 + 2] cyclotrimerization reaction (Scheme 3).

Additional control experiments, carried out with quinaldine, 2-chloro-3-formylquinoline and acridine instead of quinoline, also suggest that the cyclotrimerization reaction with *N*-sulfonylketenimine fails, indicating clearly that the second position of quinoline must be free for the reaction to occur (Scheme 4).This is also confirmed when the reaction is found to be facile when substituents are present in the 3- and 5-positions of quinoline (**4s**−**4x** in Table 2).

Based on the observed experimental results, a plausible mechanistic pathway for the three component cascade reaction is proposed (Scheme 5). Phenylacetylene and sulfonyl azide in

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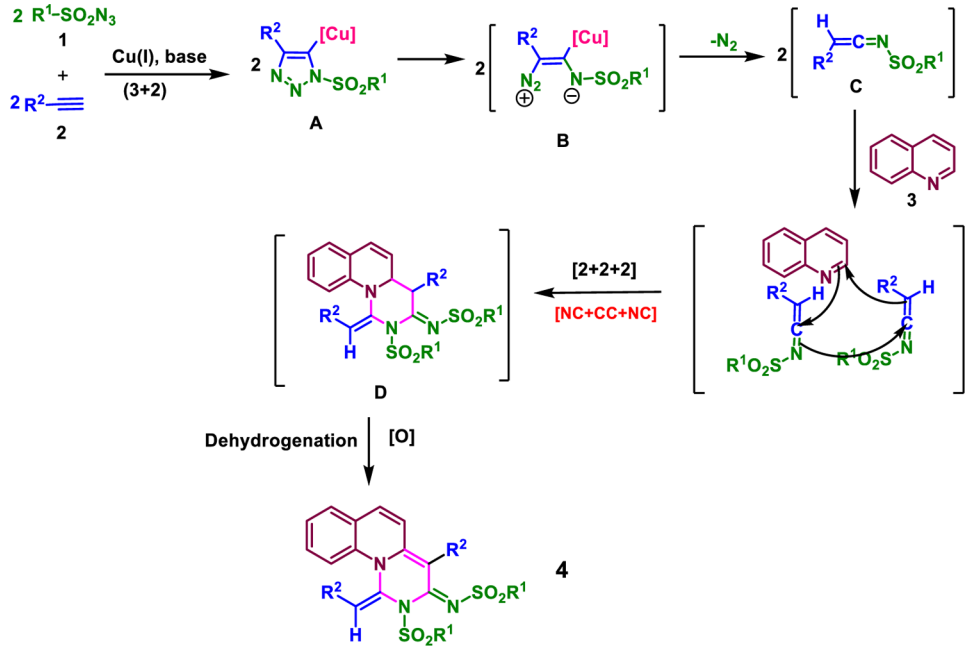
Scheme 5. Plausible Mechanism for the Cu(I)-Y Zeolite-Catalyzed Termolecular [2 + 2 + 2] Cycloaddition Reaction



the presence of Cs_2CO_3 and Cu(I)-Y zeolite form a copper triazolyl intermediate (**A**).[19] This is followed by a ring opening reaction to give (**B**)[20] which undergoes rearrangement and extrusion of nitrogen to yield *N*-sulfonylketenimine (C), simultaneously regenerating the copper catalyst. The *N*-sulfonylketenimine (C) as an energetic dipolar intermediate, reacting simultaneously as an electrophile (across C═N) as well as nucleophile (across C═C bond), undergoes addition to C═N bond of quinoline in a novel termolecular [2 + 2 + 2] cycloaddition reaction. The observed [NC + CC + NC] termolecular cycloaddition reaction occurs regio- and stereoselectively to form a dihydro intermediate (D) in a concerted manner. Subsequent dehydrogenation of intermediate (D) by air oxidation generates the pyrimido[1,6-*a*]quinoline (**4**).

The catalyst is found to be reusable. After completion of the reaction the catalyst was filtered and washed at least four times first with ethyl acetate and then water. The recovered catalyst was dried and activated at 450 °C for 6 h. Its consistent activity up to 5 consecutive cycles were tested and only marginal differences in yield were observed (see Supporting Information, Table 1). The UV-DRS of reused Cu(I)-Y zeolite shows that Cu(I) is largely intact, within the zeolite framework without any significant oxidation (see Supporting Information, Figure S5). Leaching test was performed to find out the heterogeneity of the Cu(I)-Y zeolite catalyst by reaction mixture hot filtration test. It was found to be <1 ppm in the filtrate.

In summary, we have demonstrated a regio- and stereoselective copper(I)-Y zeolite-catalyzed termolecular [2 + 2 + 2]/ [NC + CC + NC] cycloaddition cascade reaction involving two molecules of *in situ* generated *N*-sulfonylketenimines and quinoline to synthesize the highly functionalized pyrimido[1,6-*a*]quinolines. Significantly, to the best of our knowledge, this is the first report on termolecular [2 + 2 + 2] cycloaddition reaction involving two C−N bonds. The mild reaction conditions enable the utilization of a wide range of substrates that deliver products in high yield and excellent purity. This reaction utilizes inexpensive copper(I)-Y zeolite which functions simultaneously as a catalyst and also provides a confined space to effect the regio- and stereoselective cycloaddition/termolecular dehydrogenation cascade reaction giving improved yield compared to its homogeneous equivalents, and the catalyst can be reused at least five times without any marked change in the overall yield. The benefit of performing two cycloaddition reactions ([3 + 2] [2 + 2 + 2]) in one operation, significant molecular complexity generated, and remarkable simplicity of operation, renders this catalytic system potentially cost-effective and environmentally friendly.

EXPERIMENTAL SECTION

General Information. All reactions were carried out under open air atmosphere, with dry, freshly distilled solvents. All chemicals (quinolines, alkynes, sulfonyl chlorides, metal salts, and NH_4Y) were used as commercially available without further purification unless otherwise noted. NMR spectra were operating at 300, 400, and 500 MHz for ^1H and 75, 100, and 125 MHz for ^{13}C. All ^1H NMR and ^{13}C NMR spectra were measured in $CDCl_3$ with TMS as the internal standard. High-resolution mass spectra were obtained by ESI using Orbitrap mass spectrometers. IR spectra were recorded on an FT-IR spectrometer and are reported in terms of frequency of absorption (cm^{-1}). Purifications by column chromatography were performed on 60−120 mesh silica gel. The XRD pattern of the catalyst samples was measured with a PW3050/60 instrument using a CuKα radiation at room temperature. Sulfonyl azides[22] were prepared according to the published methods. The crystal structures of compounds **4b** and **4q** have been deposited at the Cambridge Crystallographic Data Centre and are allocated the deposition numbers CCDC 1041307 and 1041308.

General Procedure for Preparation of Cu^I-Y Zeolite. Cu^I-Y zeolite was prepared according to the reported procedure by Li et al.[23] A mixture of CuCl and HY (obtained from deammonification of NH_4Y at 450 °C for 6h) was ground by pestle and mortar and heated in flowing nitrogen atmosphere at a heating rate of 10 °C/min. The ion exchange of Cu(I) in solid CuCl with H^+ in HY zeolite occurred at over 300 °C, and the

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maximum ion-exchange rate was reached at 340 °C with the consequent release of HCl gas. Cu^{I}-Y was prepared at two different temperatures via heating the mixture of CuCl/HY at 350 °C for 15 h and 450 °C for 6 h under nitrogen atmosphere. After the preparation was over, the Cu^{I}-Y was kept under high vacuum. The prepared Cu^{I}-Y zeolite was characterized by powder XRD (see Supporting Information, Figure S2) and EDX which was found to be in good agreement with the literature.[18] The total copper content in the samples was determined by EDX analysis, and it was found to be 13.09 wt % (see Supporting Information, Figure S3).

General Procedure for Cu(I)-Y Zeolite-Catalyzed [2 + 2 + 2] Cycloaddition Reaction. A solution of alkyne (1 mmol) was added slowly to a mixture of Cu^{I} Y zeolite (20 mg, 10 mol %), sulfonyl azide (1 mmol), quinoline (0.5 mmol), and Cs_2CO_3 (400 mg, 1.2 mmol) taken in 3 mL of DCM under open air atmosphere at room temperature for 2 h. After the completion of reaction, the reaction mixture was diluted with ethyl acetate (5 mL). The catalyst was separated by filtration, followed by solvent evaporation under reduced pressure. The resulting crude product was finally purified by column chromatography using silica gel (60−120 mesh), ethyl acetate, and petroleum ether mixture (10%). The recovered catalyst was thoroughly washed with ethyl acetate and water and used for the next run.

(E)-N-((E)-1-Benzylidene-4-phenyl-2-tosyl-1H-pyrimido-[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide ***(4a)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 68% (228 mg); mp 160−165 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, J = 8.2 Hz, 2H), 7.46 (d, J = 8.3 Hz, 2H), 7.38−7.31 (m, 2H), 7.28 (d, J = 4.0 Hz, 2H), 7.24−7.18 (m, 2H), 7.14 (d, J = 7.1 Hz, 2H), 7.10−7.03 (m, 2H), 7.03−6.97 (m, 4H), 6.95 (t, J = 7.5 Hz, 2H), 6.85 (d, J = 8.2 Hz, 2H), 6.73 (d, J = 7.4 Hz, 2H), 6.64 (d, J = 9.5 Hz, 1H), 2.25 (s, 3H), 2.18 (s, 3H); ^{13}C {H} NMR (75 MHz, $CDCl_3$) δ 152.1, 149.2, 144.6, 141.9, 140.9, 135.4, 134.1, 133.8, 133.2, 132.2, 131.9, 131.3, 129.4, 129.2, 128.8, 128.6, 128.4, 128.2, 128.1, 127.9, 127.7, 127.6, 127.4, 126.4, 126.1, 125.2, 124.7, 123.2, 119.9, 117.8, 107.3, 21.3, 21.1; HRMS (ESI): m/z calculated for $C_{39}H_{31}O_4N_3S_2Na$ [M^+ + Na] 692.1664, found: 692.1648; IR (KBr): ν = 3474, 3064, 2923, 1660, 1603, 1496, 1456, 1278, 1221, 1163, 1129, 1078, 1021, 850, 810 cm^{-1}.

(E)-N-((E)-1-Benzylidene-4-phenyl-2-(phenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)benzenesulfonamide ***(4b)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 65% (208 mg); mp 135−140 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.19 (s, 1H), 8.10 (s, 1H), 7.82−7.77 (m, 2H), 7.72 (d, J = 9.3 Hz, 3H), 7.68 (d, J = 4.8 Hz, 1H), 7.58 (d, J = 8.6 Hz, 2H), 7.49 (dd, J = 5.8, 3.7 Hz, 3H), 7.36−7.34 (m, 2H), 7.28 (s, 1H), 7.23 (d, J = 3.0 Hz, 2H), 7.21 (d, J = 3.0 Hz, 1H), 7.05 (m, 6H), 6.81 (d, J = 7.3 Hz, 2H), 6.54 (d, J = 9.5 Hz, 1H);^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 158.0, 152.1, 149.3, 144.7, 136.3, 136.0, 134.0, 133.6, 133.0, 132.0, 131.4, 131.1, 130.5, 129.5, 128.54, 128.5, 128.3, 128.1, 128.0, 127.8, 127.5, 126.0, 125.1, 124.9, 123.2, 119.6, 117.7, 107.2; HRMS (ESI): m/z calculated for $C_{37}H_{27}O_4N_3S_2Na$ [M^+ + Na] 664.1348, found: 664.1335; IR (KBr): ν = 3435, 3055, 2924, 1959, 1716, 1603, 1499, 1296, 1227, 1161, 1119, 1063, 1023, 866, 812 cm^{-1}.

(E)-N-((E)-1-Benzylidene-4-phenyl-2-(2,4,5-trichlorophenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-2,4,5-trichlorobenzenesulfonamide ***(4c)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 51% (215 mg); mp 130−135 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31 (s, 1H), 8.14 (s, 1H), 7.83 (s, 1H), 7.58 (s, 1H), 7.55 (s, 1H), 7.50 (d, J = 6.4 Hz, 1H), 7.41 (s, 1H), 7.37 (s, 2H), 7.35 (d, J = 4.0 Hz, 5H), 7.20 (d, J = 9.3 Hz, 2H), 7.13 (d, J = 7.4 Hz, 1H), 7.06 (t, J = 7.5 Hz, 2H), 6.93 (d, J = 9.5 Hz, 1H), 6.84 (d, J = 7.4 Hz, 1H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 169.2, 153.9, 150.8, 140.9, 138.9, 138.7, 137.1, 135.6, 135.5, 135.2, 134.5, 133.9, 133.7, 133.0, 132.6, 132.5, 132.1, 131.9, 131.8, 131.7, 131.2, 130.9, 130.8, 130.71, 130.6, 130.4, 130.1, 129.9, 129.3, 128.8, 128.7, 128.6, 128.3, 127.6, 127.0, 125.4, 123.7, 123.8, 120.0, 117.6, 107.0; HRMS (ESI): m/z calculated for $C_{37}H_{21}O_4N_3Cl_6S_2Na$ [M^+ + Na] 867.9002, found: 867.8997; IR (KBr): ν = 3436, 3088, 2926, 2091, 1617, 1564, 1495, 1456, 1321, 1168, 1132, 1060, 877, 801, 752, 695, 653, 582 cm^{-1}.

(E)-N-((E)-1-Benzylidene-2-(4-bromophenylsulfonyl)-4-phenyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-bromobenzenesulfonamide ***(4d)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 64% (254 mg); mp 183−185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, J = 8.6 Hz, 5H), 7.48 (d, J = 8.1 Hz, 2H), 7.43 (d, J = 8.4 Hz, 2H), 7.41−7.38 (m, 5H), 7.30 (s, 2H), 7.21 (d, J = 7.0 Hz, 2H), 7.14 (s, 1H), 7.11 (d, J = 7.4 Hz, 1H), 7.04 (t, J = 7.5 Hz, 2H), 6.79 (dd, J = 12.4, 8.5 Hz, 3H); ^{13}C{H} NMR (101 MHz, $CDCl_3$) δ 152.3, 149.7, 143.9, 136.1, 136.1, 134.2, 133.0, 132.4, 131.8, 131.7, 131.2, 130.0, 129.8, 129.3, 128.9, 128.8, 128.5, 128.4, 128.3, 128.1, 128.0, 126.8, 125.4, 125.2, 125.0, 123.5, 120.0, 117.9, 107.4; HRMS (ESI): m/z calculated for $C_{37}H_{26}Br_2N_3O_4S_2$ [M^+ + H] 797.9726, found: 797.9728; IR (KBr): ν = 3433, 3032, 2953, 1617, 1490, 1372, 1315, 1169, 1130, 1072, 1020, 898, 872 cm^{-1}.

(E)-N-((E)-1-Benzylidene-2-(4-iodophenylsulfonyl)-4-phenyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-iodobenzenesulfonamide ***(4e)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 67% (298 mg); mp 195−198; ^{1}H NMR (300 MHz, CDC_{l3}) δ 7.62 (d, J = 8.6 Hz, 2H), 7.49 (d, J = 8.6 Hz, 4H), 7.44 (d, J = 6.9 Hz, 2H), 7.40 (d, J = 3.1 Hz, 3H), 7.38 (d, J = 3.0 Hz, 2H), 7.32 (d, J = 15.3 Hz, 2H), 7.24 (d, J = 6.9 Hz, 2H), 7.19 (d, J = 7.5 Hz, 1H), 7.11 (d, J = 6.6 Hz, 2H), 7.09−7.00 (m, 2H), 6.82 (d, J = 3.1 Hz, 1H), 6.79 (d, J = 5.5 Hz, 1H); ^{13}C {H} NMR (75 MHz, $CDCl_3$) δ152.3, 149.8, 144.6, 137.7, 137.2, 136.7, 136.2, 134.2, 130.0, 132.4, 131.8, 131.1, 129.8, 128.9, 128.8, 128.6, 128.4, 128.3, 128.1, 127.97, 125.2, 124.9, 123.5, 120.0, 117.9, 107.4, 101.5, 97.70; HRMS (ESI): m/z calculated for $C_{37}H_{26}O_4N_3I_2S_2$ [M^+ + H] 893.9448, found: 893.9451; IR (KBr): ν = 3420, 3077, 1606, 1565, 1493, 1449, 1374, 1280, 1226, 1168, 1124, 1080, 848, 804, 744, 600, 525 cm^{-1}.

(E)-N-((E)-1-Benzylidene-2-(4-nitrophenylsulfonyl)-4-phenyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-nitrobenzenesulfonamide ***(4f)***. Compound is prepared according to the general procedure. Reddish colored solid; yield 58% (212 mg); mp 160−165 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, J = 7.6 Hz, 2H), 7.65 (d, J = 7.7 Hz, 2H), 7.48 (d, J = 8.5 Hz, 1H), 7.43−7.38 (m, 2H), 7.33 (s, 5H), 7.29 (d, J = 4.1 Hz, 1H), 7.24 (s, 1H), 7.18−7.12 (m, 5H), 7.08 (d, J = 7.1 Hz, 1H), 7.02 (t, J = 7.3 Hz, 2H), 6.80 (d, J = 7.3 Hz, 2H), 6.67 (d, J = 9.4 Hz, 1H); ^{13}C{H} NMR (100 MHz, $CDCl_3$) δ 152.4, 149.3, 144.9, 137.0, 135.7, 134.3, 133.6, 133.24, 132.4, 131.9, 131.5, 131.4, 130.7, 129.5, 128.7, 128.5, 128.4, 128.2, 128.1, 128.0, 127.9, 127.8, 126.3, 125.5, 124.8, 123.4, 120.0, 118.0, 107.4; HRMS (ESI): m/z calculated for $C_{37}H_{26}N_5O_8S_2$ [M^+ + H] 732.1217,

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found: 732.1212; IR (KBr): ν = 3437, 3025, 2923, 1605, 1495, 1445, 1385, 1310, 1232, 1162, 1135, 1090, 1019, 876 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-2-(naphthalen-2-ylsulfonyl)-4-phenyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-naphthalene-2-sulfonamide (**4g**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 53% (196 mg); mp 195−200 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, J = 12.0 Hz, 2H), 7.73 (d, J = 4.9 Hz, 1H), 7.71 (d, J = 3.7 Hz, 1H), 7.65 (d, J = 3.7 Hz, 1H), 7.63 (d, J = 4.0 Hz, 2H), 7.61 (d, J = 5.3 Hz, 1H), 7.51 (d, J = 8.7 Hz, 1H), 7.45 (d, J = 7.7 Hz, 2H), 7.42−7.37 (m, 2H), 7.31 (d, J = 7.3 Hz, 2H), 7.25−7.21 (m, 2H), 7.19 (s, 2H), 7.16 (d, J = 9.2 Hz, 2H), 7.10 (d, J = 6.5 Hz, 2H), 7.03 (d, J = 3.1 Hz, 1H), 7.01 (d, J = 6.2 Hz, 2H), 6.94 (t, J = 7.5 Hz, 2H), 6.74 (d, J = 7.4 Hz, 2H), 6.47 (d, J = 9.5 Hz, 1H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 170.8, 151.9, 149.4, 141.7, 135.8, 134.4, 133.6, 133.0, 132.9, 132.4, 131.8, 131.6, 131.1, 130.8, 129.4, 129.0, 128.7, 128.6, 128.4, 128.2, 128.1, 128.0, 127.8, 127.4, 127.3, 127.2, 126.2, 125.9, 124.8, 124.6, 122.9, 122.6, 121.7, 119.3, 117.3, 107.1; HRMS (ESI): m/z calculated for $C_{45}H_{31}O_4N_3S_2Na$ [M^++ Na] 764.1660, found: 764.1648; IR (KBr): ν = 3427, 3059, 2922, 2855, 1619, 1497, 1460, 1291, 1230, 1118, 1066, 866 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-2-(methylsulfonyl)-4-phenyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)methanesulfonamide (**4h**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 57% (147 mg); mp 145−150 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (s, 1H), 7.44 (d, J = 6.4 Hz, 5H), 7.36 (d, J = 8.4 Hz, 2H), 7.19 (s, 1H), 7.12 (d, J = 5.9 Hz, 1H), 7.09−7.04 (m, 3H), 6.98 (d, J = 5.9 Hz, 1H), 6.96 (d, J = 5.9 Hz, 1H), 6.86 (d, J = 7.3 Hz, 2H), 3.72 (s, 3H), 2.90 (s, 3H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 152.4, 150.0, 136.1, 134.2, 133.8, 132.5, 131.3, 130.5, 129.6, 128.7, 128.4, 128.3, 128.0, 127.7, 126.5, 124.6, 123.7, 120.4, 118.2, 107.37, 43.3, 43.0; HRMS (ESI): m/z calculated for $C_{27}H_{23}O_4N_3S_2Na$ [M^+ + Na] 540.1021, found: 540.1022; IR (KBr): ν = 3432, 3034, 2929, 1611, 1503, 1464, 1315, 1275, 1155, 1113, 1057, 962, 842,806 cm^{-1}.

*(E)-N-((E)-1-(2-Methoxybenzylidene)-4-(2-methoxyphenyl)-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**4i**).* Compound is prepared according to the general procedure. Orange colored solid; yield 76% (277 mg); mp 210−215 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (s, 2H), 7.60 (d, J = 8.2 Hz, 2H), 7.48 (d, J = 8.5 Hz, 1H), 7.34 (s, 1H), 7.31 (d, J = 11.9 Hz, 2H), 7.21 (s, 1H), 7.12 (d, J = 8.0 Hz, 2H), 7.05 (d, J = 7.7 Hz, 4H), 6.97 (d, J = 8.1 Hz, 2H), 6.87−6.83 (m, 2H), 6.65 (d, J = 8.3 Hz, 1H), 6.62−6.56 (m, 2H), 6.49 (s, 1H), 3.70 (s, 3H), 3.46 (s, 3H), 2.31 (s, 3H), 2.28 (s, 3H); ^{13}C {H} NMR (75 MHz, $CDCl_3$) δ 162.5, 158.2, 156.9, 152.5, 149.9, 144.3, 142.8, 140.5, 135.2, 134.9, 130.7, 130.4, 129.4, 128.9, 128.7, 128.40, 128.2, 127.5, 127.3, 126.5, 126.3, 124.3, 123.3, 122.5, 121.4, 120.5, 120.2, 117.8, 111.3, 110.5, 102.5, 55.6, 55.4, 21.4, 21.2; HRMS (ESI): m/z calculated for $C_{41}H_{36}N_3O_6S_2$ [M^+ + H] 730.2040, found: 730.2054; IR (KBr): ν = 3432, 3034, 2929, 1611, 1503, 1464, 1315, 1275, 1155, 1113, 1057, 962, 871, 842 cm^{-1}.

*(E)-4-Methyl-N-((E)-1-(4-methylbenzylidene)-4-p-tolyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4j**).* Compound is prepared according to the general procedure. Orange colored solid; yield 74% (258 mg); mp 178−180 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.63 (d, J = 8.2 Hz, 2H), 7.51 (d, J = 8.3 Hz, 2H), 7.43 (dd, J = 11.7, 8.2 Hz, 2H), 7.29 (s, 1H), 7.18 (dd, J = 11.4, 7.5 Hz, 4H), 7.14−7.05 (m, 4H), 7.01 (s, 1H), 6.91 (d, J = 8.3 Hz, 2H), 6.83 (d, J = 8.0 Hz, 2H), 6.73 (d, J = 9.6 Hz, 1H), 6.68 (d, J = 8.1 Hz, 2H), 2.40 (s, 3H), 2.34 (s, 3H), 2.25 (s, 3H), 2.17 (s, 3H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ152.4, 149.2, 144.4, 142.1, 140.8, 139.8, 137.3, 135.2, 134.3, 134.1, 132.1, 131.8, 131.4, 130.3, 129.0, 128.8, 128.7, 128.4, 127.8, 126.3, 124.6, 124.4, 123.3, 120.2, 117.9, 107.2, 21.4, 21.3, 21.2 (2CH_3 carbons are merged). HRMS (ESI): m/z calculated for $C_{41}H_{36}O_4N_3S_2$ [M^+ + H] 698.2141, found: 698.2144; IR (KBr): ν = 3448, 3036, 2947, 1613, 1492, 1448, 1273, 1227, 1160, 1135, 1073, 1025, 858, 812 cm^{-1}.

*(E)-4-Methyl-N-((E)-1-(3-methylbenzylidene)-4-m-tolyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4k**).* Compound is prepared according to the general procedure. Orange colored solid; yield 71% (247 mg); mp 198−200 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62 (d, J = 8.3 Hz, 2H), 7.55 (d, J = 8.3 Hz, 2H), 7.42 (t, J = 8.2 Hz, 3H), 7.29 (d, J = 9.6 Hz, 2H), 7.22 (d, J = 8.6 Hz, 2H), 7.15 (d, J = 7.6 Hz, 2H), 7.10 (d, J = 8.2 Hz, 2H), 7.03 (s, 1H), 6.95 (d, J = 7.9 Hz, 3H), 6.89 (d, J = 5.7 Hz, 2H), 6.75 (d, J = 9.5 Hz, 1H), 6.62 (s, 1H), 6.57 (d, J = 3.7 Hz, 1H), 2.34 (s, 3H), 2.31(s,3H), 2.27 (s, 3H), 2.05 (s, 3H); ^{13}C {H} NMR (100 MHz, $CDCl_3$) δ 152.5, 149.1, 144.6, 142.1, 141.0, 138.1, 137.7, 135.1, 134.5, 133.3, 133.1, 131.9, 131.4, 130.3, 129.8, 129.3, 129.0, 128.6, 128.4, 128.2, 128.1, 128.0, 127.8, 126.5, 125.8, 125.5, 124.6, 123.4, 120.3, 118.1, 107.6, 21.7, 21.5, 21.4, 21.0; HRMS (ESI): m/z calculated for $C_{41}H_{36}N_3O_4S_2$: 698.2142, found: [M^+ + H] 698.2147; IR (KBr): ν = 3446, 3045, 2925, 1615, 1499, 1443, 1365, 1283, 1220, 1175, 1123, 1071, 1029, 862, 812, 783 cm^{-1}.

*(E)-N-((E)-1-(4-Bromobenzylidene)-4-(4-Bromophenyl)-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methyl-benzenesulfonamide (**4l**).* Compound is prepared according to the general procedure. orange colored solid; yield 70% (289 mg); mp 163−165 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.62 (d, J = 8.3 Hz, 3H), 7.54−7.46 (m, 5H), 7.42 (d, J = 8.7 Hz, 2H), 7.36−7.28 (m, 3H), 7.23−7.17 (m, 3H), 7.15 (d, J = 4.8 Hz, 2H), 7.12−7.06 (m, 3H), 7.00−6.92 (m, 3H), 6.67 (t, J = 9.6 Hz, 3H), 2.36 (s, 3H), 2.27 (s, 3H); ^{13}C {H} NMR (75 MHz, $CDCl_3$) δ 151.9,148.9, 144.8, 141.8, 141.7, 141.3, 136.2, 135.8, 134.3, 134.1, 132.8, 131.7, 131.3, 131.0, 130.4,130.3, 130.1, 129.5, 129.0, 128.6, 128.2, 128.0, 127.8, 126.7, 126.5, 126.3, 126.0, 125.0, 123.9, 123.3, 121.9, 119.7, 117.9, 105.9, 21.4, 21.3. HRMS (ESI): m/z calculated for $C_{39}H_{30}N_3O_4$ Br_2S_2: 826.0039, found: [M^+ + H] 826.0047; IR (KBr): ν = 3438, 3047, 2931, 1615, 1488, 1375, 1308, 1171, 1138, 1084, 1026, 895, 874 cm^{-1}.

*(E)-4-Bromo-N-((E)-1-(4-Bromobenzylidene)-4-(4-Bromophenyl)-2-(4-Bromophenylsulfonyl)-1H-pyrimido[1,6-a]-quinolin-3(2H)-ylidene)benzenesulfonamide (**4m**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 73% (347 mg); mp 185−188 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.20 (d, J = 7.6 Hz, 1H), 8.13 (d, J = 8.5 Hz, 1H), 7.80 (d, J = 8.7 Hz, 1H), 7.74 (s, 1H), 7.64 (d, J = 3.6 Hz, 1H), 7.61 (d, J = 3.6 Hz, 1H), 7.57 (s, 1H), 7.53 (d, J = 4.5 Hz, 2H), 7.50 (d, J = 4.2 Hz, 1H), 7.46 (d, J = 6.0 Hz, 2H), 7.42 (s, 1H), 7.38 (s, 1H), 7.31 (d, J = 8.7 Hz, 2H), 7.19 (d, J = 8.5 Hz, 2H), 7.12−7.06 (m, 2H), 7.04 (d, J = 3.7 Hz, 1H), 6.76 (d, J = 9.5 Hz, 1H), 6.66 (d, J = 8.5 Hz, 1H). ^{13}C {H} NMR (75 MHz, $CDCl_3$) δ 168.8, 151.4, 149.7,149.1, 147.5, 143.2, 142.1, 137.6, 136.6, 135.7, 135.3, 133.3, 133.6, 133.3, 131.7, 131.4, 131.4, 131.3, 131.0, 130.9, 130.8, 130.6, 129.8, 129.3, 129.2, 129.0, 128.6, 128.2, 128.0, 127.3, 127.3, 127.2, 126.0,

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125.9, 125.2, 125.0, 124.6, 123.8, 123.0, 121.6, 120.6, 119.04, 117.0, 105.3; HRMS (ESI): m/z calculated for $C_{37}H_{24}N_3O_4Br_4S_2$: 953.7936, found: [$M^+$ + H] 953.7941; IR (KBr): ν = 3436, 3027, 2936, 1617, 1496, 1368, 1313, 1168, 1130, 1080, 1022, 892, 874, 860, 842 cm^{-1}.

*(E)-4-Methyl-N-((E)-1-(4-nitrobenzylidene)-4-(4-nitrophenyl)-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4n**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 50% (190 mg); mp 190−195 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.29 (d, J = 4.4 Hz, 1H), 8.21 (d, J = 8.8 Hz, 2H), 8.12 (d, J = 8.5 Hz, 1H), 7.91 (d, J = 8.8 Hz, 2H), 7.75 (d, J = 8.3 Hz, 1H), 7.61 (d, J = 8.2 Hz, 2H), 7.52−7.46 (m, 4H), 7.42 (d, J = 7.3 Hz, 4H), 7.15 (d, J = 7.2 Hz, 3H), 6.99 (d, J = 8.5 Hz, 3H), 6.73 (d, J = 9.5 Hz, 1H), 2.38 (s, 3H), 2.31 (s, 3H); ^{13}C {H} NMR (101 MHz, $CDCl_3$) δ 171.3, 151.6, 149.0, 147.7, 147.2, 145.6, 142.3, 141.0, 140.3, 137.6, 137.1, 134.0, 133.6, 133.4, 132.4, 130.1, 129.7, 129.4, 129.0, 128.6, 127.9, 126.3, 125.8, 123.7, 123.4, 119.2, 117.6, 105.2, 21.5, 21.0; HRMS (ESI): m/z calculated for $C_{39}H_{30}N_5O_8S_2$ [M^+ + H] 760.1530, found: 760.1534; IR (KBr): ν = 3421, 3027, 2919, 1596, 1495, 1456, 1431, 1370, 1303, 1237, 1164, 1135, 1085, 1039, 874 cm^{-1}.

*(E)-N-((E)-4-Cyclopropyl-1-(Cyclopropylmethylene)-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**4o**).* Compound is prepared according to the general procedure. Orange colored solid; yield 53% (158 mg); mp 145−148 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.95 (d, J = 8.4 Hz, 1H), 7.89 (d, J = 8.1 Hz, 2H), 7.65 (dd, J = 10.8, 9.5 Hz, 4H), 7.36 (t, J = 7.6 Hz, 2H), 7.30 (d, J = 8.1 Hz, 2H), 7.02 (d, J = 8.4 Hz, 2H), 6.86 (d, J = 8.1 Hz, 2H), 2.45 (s, 3H), 2.30 (s, 3H), 2.17 (t, J = 7.8 Hz, 1H), 1.26 (t, J = 7.1 Hz, 1H), 1.02 (d, J = 5.7 Hz, 1H), 0.88 (d, J = 6.5 Hz, 1H), 0.71 (d, J = 6.6 Hz, 3H), 0.64−0.49 (m, 2H), 0.16 (d, J = 5.6 Hz, 1H) ;^{13}C {H} NMR (75 MHz, $CDCl_3$) δ 156.4, 151.8, 143.9, 142.2, 141.2, 136.4, 136.0, 135.8, 135.4, 131.5, 129.5, 129.1, 128.6, 128.3, 127.8, 127.4, 126.9, 125.4, 124.8, 123.2, 120.5,117.9, 105.6, 21.4 ($2CH_3$ carbons are merged), 11.46, 11.03, 10.24, 8.91, 8.77, 6.94; HRMS (ESI): m/z calculated for $C_{33}H_{32}N_3O_4S_2$ [M^+ + H] 598.1828, found: 598.1821; IR (KBr): ν = 3427, 3051, 2932, 1614, 1496, 1448, 1296, 1160, 1085, 1026, 936, 918, 868, 842, 828 cm^{-1}.

*(E)-N-((E)-4-Cyclopropyl-1-(cyclopropylmethylene)-2-(phenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4p**).* Compound is prepared according to the general procedure. Orange colored solid; yield 46% (130 mg); mp 155−160 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, J = 6.5 Hz, 6H), 7.89 (d, J = 8.7 Hz, 3H), 7.62 (t, J = 7.1 Hz, 6H), 7.57 (t, J = 7.1 Hz, 7H), 7.44 (d, J = 2.4 Hz, 3H), 7.41 (s, 3H), 7.35−7.29 (m, 6H), 7.19 (s, 6H), 7.08 (d, J = 8.4 Hz, 6H), 7.01 (t, J = 7.9 Hz, 6H), 2.10 (t, J = 8.0 Hz, 3H), 1.21 (dd, J = 13.3, 7.4 Hz, 6H), 0.99−0.93 (m, 3H), 0.83−0.79 (m, 3H), 0.67−0.62 (m, 6H), 0.55−0.50 (m, 3H), 0.50−0.45 (m, 4H), 0.12−0.06 (m, 3H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 156.5, 152.0, 144.8, 139.3, 136.4, 136.1, 135.5, 133.0, 131.7, 130.9, 128.6, 128.4, 128.1, 127.2, 126.9, 125.3, 124.9, 123.3, 120.5, 118.0, 105.7, 11.5, 11.1, 10.1, 9.0, 8.8, 7.0; HRMS (ESI): m/z calculated for $C_{31}H_{28}N_3O_4S_2$ [M^+ + H] 570.1516, found: 570.1512; IR (KBr): ν = 3430, 3066, 2925, 1616, 1504, 1461, 1284, 1142, 1078, 1029, 952, 910, 855, 812 cm^{-1}.

*(E)-N-((E)-4-Cyclohexyl-1-(cyclohexylmethylene)-2-(phenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4q**).* Compound is prepared according to the general procedure. Orange colored solid; yield 56% (189 mg); mp 170−175 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (t, J = 7.4 Hz, 3H), 7.66 (t, J = 7.9 Hz, 1H), 7.49 (d, J = 6.3 Hz, 3H), 7.44 (s, 2H), 7.40 (d, J = 6.4 Hz, 1H), 7.36 (d, J = 7.4 Hz, 1H), 7.30 (d, J = 9.6 Hz, 1H), 7.23 (d, J = 7.5 Hz, 1H), 6.97 (t, J = 7.9 Hz, 2H), 6.83 (d, J = 9.7 Hz, 1H), 5.90 (d, J = 10.6 Hz, 1H), 2.17 (s, 1H), 1.73 (d, J = 12.0 Hz, 8H), 1.51 (s, 1H), 1.32−1.25 (m, 4H), 1.18−1.06 (m, 4H), 1.06−0.97 (m, 4H); ^{13}C{H} NMR (101 MHz, $CDCl_3$) δ 145.2, 142.5, 137.5, 136.9, 135.7, 135.0, 133.2, 132.1, 130.6, 128.2, 128.1, 128.0, 127.6, 127.5, 126.4, 126.1, 125.0, 124.7, 123.3, 118.5, 117.2, 38.5, 35.4, 32.8, 31.8, 29.4, 28.5, 27.3, 26.9, 25.9, 25.6, 25.1, 24.9; HRMS (ESI): m/z calculated for $C_{37}H_{39}O_4N_3S_2Na$ [M^+ + Na] 676.2296, found: 676.2274; IR (KBr): ν = 3431, 3065, 2923, 2849, 2242, 1675, 1612, 1449, 1374, 1290, 1228, 1172, 1136, 1078, 1020, 912, 874, 836 cm^{-1}.

*(E)-N-((E)-4-Cyclohexenyl-1-(Cyclohexenylmethylene)-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide(**4r**).* Compound is prepared according to the general procedure. Orange colored solid; yield 59% (200 mg); mp 166−170 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.21 (d, J = 8.3 Hz, 1H), 8.13 (d, J = 8.5 Hz, 1H), 7.97 (s, 1H), 7.86 (d, J = 8.2 Hz, 2H), 7.78−7.72 (m, 2H), 7.63−7.54 (m, 2H), 7.44 (dd, J = 8.3, 4.2 Hz, 2H), 7.34 (d, J = 8.0 Hz, 4H), 2.44 (d, J = 3.8 Hz, 6H), 1.53 (s, 18H). ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 171.2, 149.9, 144.7, 136.5, 134.7, 130.9, 129.6, 129.5, 129.4, 129.1, 128.7, 128.7, 128.2, 127.8, 127.7, 127.5, 126.6, 126.3, 121.1, 34.5, 29.6, 27.8, 26.8, 25.5, 25.2, 24.9, 24.6, 23.9, 22.5, 21.5(2-CH_3 carbons are merged), 20.9, 14.1; HRMS (ESI): m/z calculated for $C_{39}H_{40}O_4N_3S_2$ [M^+ + H] 678.2455, found 678.2452; IR (KBr): ν = 3438, 3047, 2947, 2875, 2210, 1656, 1605, 1486, 1385, 1283, 1235, 1170, 1132, 1095, 1022, 895, 858, 802 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-8-nitro-4-phenyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**4s**).* Compound is prepared according to the general procedure. Reddish colored solid; mp 175−180 °C; yield 56% (213 mg); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.67 (d, J = 10.0 Hz, 1H), 7.62 (d, J = 8.1 Hz, 2H), 7.53 (d, J = 8.2 Hz, 2H), 7.40−7.36 (m, 3H), 7.33 (d, J = 8.4 Hz, 2H), 7.24−7.20 (m, 2H), 7.16 (d, J = 7.2 Hz, 2H), 7.12−7.07 (m, 5H), 6.97 (d, J = 8.1 Hz, 2H), 6.83 (d, J = 5.6 Hz, 2H), 2.34 (s, 3H), 2.29 (s, 3H); ^{13}C{H} NMR (101 MHz, $CDCl_3$) δ 152.2, 147.9, 145.3, 143.2, 141.9, 141.1, 138.6, 134.4, 133.4, 132.5, 132.3, 131.0, 130.1, 129.63, 129.5, 129.4, 129.3, 128.9, 128.8, 128.6, 128.4, 128.3, 126.6, 126.4, 125.4, 125.3, 123.4, 123.0, 122.8, 118.4, 110.1, 21.7, 21.6; HRMS (ESI): m/z calculated for $C_{39}H_{30}O_6N_4S_2Na$ [M^++ Na] 737.1514, found: 737.1499; IR (KBr): ν = 3430, 3045, 2937, 1610, 1515, 1335, 1293, 1135, 1078, 917, 847, 815 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-8-nitro-4-phenyl-2-(phenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4t**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 61% (216 mg); mp 180−183 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.20 (d, J = 7.4 Hz, 1H), 8.13 (d, J = 8.5 Hz, 1H), 7.85 (d, J = 8.1 Hz, 1H), 7.73 (dd, J = 6.7, 6.4 Hz, 3H), 7.60−7.55 (m, 2H), 7.51 (s, 1H), 7.45 (d, J = 7.2 Hz, 3H), 7.40 (d, J = 5.6 Hz, 2H), 7.32 (dd, J = 8.5, 8.1 Hz, 5H), 7.25−7.16 (m, 3H), 7.12 (dd, J = 14.2, 9.0 Hz, 3H), 6.88−6.82 (m, 1H). ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 150.2, 148.0, 137.5, 136.3, 134.0, 133.4, 132.3, 132.0, 131.3, 131.0, 130.1, 129.6, 129.2, 128.9, 128.5, 128.4, 128.3, 128.2, 127.8, 127.3, 126.6, 126.57, 125.4, 123.4, 122.7, 121.1, 118.3, 108.8; HRMS (ESI): m/z calculated for

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$C_{37}H_{27}O6N_4S_2$ [M^+ + H] 687.1367, found 687.1375; IR (KBr): ν = 3427, 3062, 2925, 1617, 1499, 1338, 1305, 1146, 1081, 904, 815 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-7-chloro-4-phenyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**4u**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 65% (230 mg); mp 180−185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, J = 8.8 Hz, 1H), 7.67 (d, J = 10.0 Hz, 1H), 7.62 (d, J = 8.3 Hz, 2H), 7.54 (d, J = 8.3 Hz, 2H), 7.38 (d, J = 3.2 Hz, 2H), 7.34 (d, J = 8.5 Hz, 2H), 7.23 (d, J = 4.0 Hz, 2H), 7.20 (d, J = 8.1 Hz, 1H), 7.18−7.13 (m, 2H), 7.10 (d, J = 8.8 Hz, 3H), 7.06 (d, J = 7.8 Hz, 2H), 6.97 (d, J = 8.1 Hz, 2H), 6.83 (d, J = 8.3 Hz, 2H), 2.34 (s, 3H), 2.30 (s, 3H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 171.1, 152.2, 148.3, 144.8, 141.8, 141.3, 135.6, 134.2, 132.9, 132.3, 132.1, 132.0, 131.2, 131.0, 130.6, 130.1, 129.6, 129.4, 129.0, 128., 128.6, 128.5, 128.2, 127.9, 127.6, 126.9, 126.4, 126.3, 125.3, 124.8, 124.1, 121.3, 121.1, 116.6, 108.0, 21.4, 21.3; HRMS (ESI): m/z calculated for $C_{39}H_{30}O_4N_3ClS_2Na$ [M^+ + Na] 726.1240, found: 726.1258; IR (KBr): ν = 3447, 3035, 2938, 2235, 1695, 1617, 1496, 1445, 1305, 1239, 1168, 1089, 1023, 858, 745, 702 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-7-chloro-4-phenyl-2-(phenylsulfonyl)-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-benzenesulfonamide (**4v**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 69% (234 mg); mp 190−195 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.73 (d, J = 7.4 Hz, 2H), 7.69−7.63 (m, 2H), 7.58 (d, J = 8.2 Hz, 1H), 7.52−7.44 (m, 3H), 7.42 (d, J = 4.0 Hz, 1H), 7.41−7.34 (m, 5H), 7.32 (d, J = 7.9 Hz, 2H), 7.23 (d, J = 7.6 Hz, 2H), 7.16 (dd, J = 4.2, 4.7 Hz, 3H), 7.11 (d, J = 7.1 Hz, 2H), 7.06 (d, J = 6.8 Hz, 1H), 6.80 (t, J = 9.2 Hz, 2H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 148.5, 144.3, 142.2, 136.8, 135.6, 133.8, 133.0, 132.7, 132.2, 131.2, 131.1, 130.9, 130.2, 129.7, 129.4, 129.2, 129.1, 128.9, 128.6, 128.6, 128.3, 128.2, 128.0, 127.9, 127.8, 127.3, 127.1, 126.6, 126.4, 126.3, 126.2, 125.2, 125.1, 121.9, 121.1, 116.6, 108.0; HRMS (ESI): m/z calculated for $C_{37}H_{27}O_4N_3ClS_2$ [M^+ + H] 676.1126, found 676.1122; IR (KBr): ν = 3429, 3061, 2927, 2249, 1965, 1715, 1605, 1500, 1438, 1295, 1231, 1142, 1081, 1034, 907,869, 728, 692 cm^{-1}.

*(E)-N-((E)-1-Benzylidene-5-bromo-4-phenyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**4x**).* Compound is prepared according to the general procedure. Reddish colored solid; yield 26% (97 mg); mp 105−110 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, J = 10.0 Hz, 1H), 7.62 (d, J = 8.3 Hz, 2H), 7.54 (d, J = 8.3 Hz, 2H), 7.39−7.32 (m, 5H), 7.22 (d, J = 7.9 Hz, 3H), 7.10 (d, J = 8.8 Hz, 4H), 7.06 (d, J = 7.8 Hz, 3H), 6.97 (d, J = 8.1 Hz, 2H), 6.83 (d, J = 8.3 Hz, 2H), 2.34 (s, 3H), 2.30 (s, 3H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 162.8, 151.0, 144.6, 144.1, 137.4, 136.5, 135.3, 135.1, 134.3, 132.5, 131.3, 131.0, 129.8, 129.6, 129.2, 129.1 (4 carbons are merged), 129.0, 128.6, 128.4, 128.1, 127.8 (2 carbons are merged), 126.9, 126.6, 126.0, 122.6, 21.4 (2 carbons are merged); HRMS (ESI): m/z calculated for $C_{39}H_{31}BrN_3O_4S_2$ [M^+ + H] 748.0939, found 748.0944; IR (KBr): ν = 3431, 3047, 2932, 1610, 1498, 1378, 1323, 1172, 1133, 1083, 1025, 915, 868 cm^{-1}.

*(E)-N-((E/Z)-1-(Cyclopropylmethylene)-4-phenyl-2-tosyl-1H-pyrimido[1,6-a]quinolin-3(2H)-ylidene)-4-methylbenzenesulfonamide (**5**) (E:Z = 23:77%).* Compound is prepared according to the general procedure. Reddish colored solid; yield 56% (177 mg); mp 161−165 °C; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.87−8.01 (dd, J = 9.0, 12.0 Hz, 1.96 H), 7.69 (dd, J = 12.0, 9.0 Hz, 3.32 H), 7.63−7.56 (m, 3.74 H), 7.51 (t, J = 9.0 Hz, 4.57 H), 7.32−7.39 (m, 7.59 H), 7.25 (d, J = 9.0 Hz, 3.21 H), 7.09 (d, J = 9.0 Hz, 3.05 H), 6.93 (t, J = 9.0 Hz, 3.20 H), 6.57−6.70 (dd, J = 9.0, 12.0 Hz, 1.36 H), 5.53−5.65 (dd, J = 9.0, 12.0 Hz, 1.30 H), 2.35 (s, 4.60 H), 2.25 (s, 4.53 H), 1.29−0.46 (m, 9.13 H); ^{13}C{H} NMR (75 MHz, $CDCl_3$) δ 152.5, 149.2, 144.3, 142.2, 140.7, 139.5, 135.9, 134.7, 134.3, 133.8,132.1, 131.4, 129.7, 129.5, 128.8,128.4, 128.1, 128.0, 127.5, 126.3, 126.3, 124.9, 124.7, 123.8, 123.2, 120.2, 119.9, 118.5, 117.0, 107.2, 21.4, 21.2, 12.2, 10.1, 9.4, 8.7, 8.1, 7.2; HRMS (ESI): m/z calculated for $C_{36}H_{32}N_3O_4S_2$ [M^+ + H] 634.1829, found 634.1835; IR (KBr): ν = 3433, 3057, 2927, 2237, 1610, 1488, 1455, 1435, 1362, 1276, 1162, 1127, 1081, 1054, 1026, 867 cm^{-1}.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.5b01896.

^{1}H, ^{13}C NMR, HRMS (ESI) spectra and X-ray crystal data of compound **4b** and **4q**. Tables of selected results, EDX and PXRD of copper(I)-Y zeolite (PDF)

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Notes

The authors declare no competing financial interest.

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