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Electrophilic cyclization of 2-Aminophenylprop-1-yn-3-ols to 3-Iodo-6-(aryldiazenyl)quinolines in a one-pot, Azo-coupling and Iodo-cyclization sequence

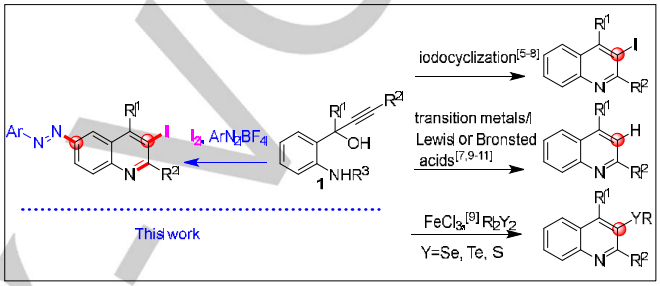
Srinivasarao Yaragorla* and Abhishek Pareek

Dedication ()

Abstract: The first synthesis of 3-iodo-6-(aryldiazenyl)quinolines is described from easily available 2-aminoaryl propargyl alcohols, aryldiazonium salts and molecular iodine (3-component reaction). The reaction proceedes through a one-pot, azo-coupling followed by regioselective iodocyclization and aromatization cascade to yield the quinoline derivatives. In the absence of iodine, $Ca(OTf)_2$ promoted the azo-coupling and azacyclization to-furnish the substituted 6-aryldiazenyl quinolines. In addition, 2-aminoaryl propargyl alcohols alone gave the 2,4-disubstituted quinolines with Ca(II). We also demonstrated the synthetic transformations of these iodoquinolines in cross-coupling reactions without disturbing the diazo functionality.

Introduction

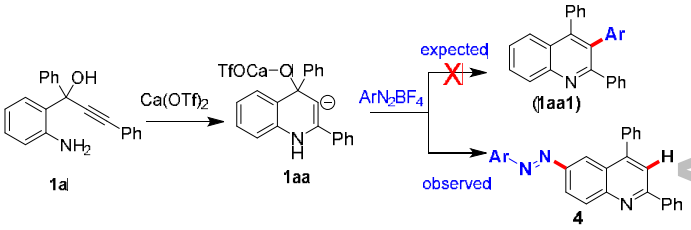
Quinolines are ubiquitous natural alkaloids with a wide range of biological and medicinal importance,[1] showed applications in material science,[2] and asymmetric catalysis.[3] Owing to these outstanding topographies, synthesis of quinolines and their derivatives become an active and challenging area of organic synthesis. Amongst many synthetic protocols developed for the synthesis of quinoline derivatives, electrophilic cyclization[4a-4f] is considered to be one of the most important atom and step economic synthesis. Most of these electrophilic cyclizations involved the interaction of an electrophilic reagent with the unsaturated carbon-carbon bonds, followed by subsequent intramolecular addition of nitrogen-nucleophile (aza-cyclization) to give the privileged- quinoline scaffolds (Scheme 1). For example, propargyl alcohol **1** was treated with electrophilic iodine under various conditions to get the 3-iodoquinolines.[5-8] Stein *et al*. reported the synthesis of 3-organoseleno-substituted quinolines through electrophilic cyclization of **1** with 1.5 equiv. of $FeCl_3$,[9] they had also described the synthesis of quinolines bearing organo tellurium and sulfur in the 3-position. The intramolecular azacyclization of **1** to the simple, 2,3-disubstituted quinolines was reported using, $FeCl_3$,[9] $CuCl_2$[10-11] and PPTS.[7] Very recently, we have reported a technically valuable method for the one-pot scalable synthesis of 3-iodoquinolines from readily available 2-arylamino ketones and terminal alkynes.[8]
In continuation of our research interest towards the synthesis of quinoline derivatives and electrophilic cyclizations, herein we report the first one-pot synthesis of 3-iodo-6(aryldiazebyl)quinolines from 2-aminoaryl propargyl alcohols.[12,15]



Scheme 1. Synthesis of quinoline derivatives from **1** via electrophilic cyclization strategy

Results and Discussion

As described in the Scheme 2, initially we aimed to the synthesis of 2,3,4-triaryl quinoline (**1aa1**) by treating the 1-(2-aminophenyl)-1,3-diphenylprop-2-yn-1-ol (**1a**) with (4-NO_2)PhN_2BF_4 (**2a**) under the calcium catalysis (Scheme 2). Presuming that the aryldiazonium salts are the synthons of arylium cations,[13] Surprisingly, the obtained product was confirmed as 6-aryl diazoquinoline along with a simple quinoline (**5a**). That means the azo-coupling took place on the para-position of aniline **1a**,[14] then followed the aza-cyclization to result in the formation of **4a**. After a careful understanding of this serendipitous result, we realized that there is still a scope to install the iodide in the third position of quinoline **4a**.



Scheme 2. Initial reaction

Accordingly, we planned our experiments to optimize the reaction conditions (Table 1). The mixture of 1a and 2a along with 10 mol% $Ca(OTf)_2$/Bu_4NPF_6 were heated directly at 100 °C for 8 h, and we obtained the mixture of two products **4a** and **5a** (entry 1, Table 1). When we repeated the same combination of reactants and refluxed the reaction mixture in DCE the yield of

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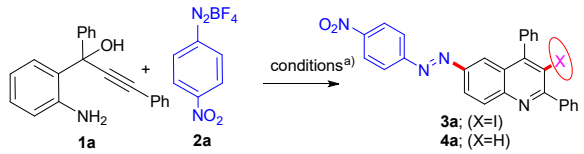
4a was increased from 5% to 35% (entry 2). Gratifyingly, the reaction in DCE at rt gave the maximum yield of **4a** (71%, entry 3) with 8% **5a**. Encouraged by this observation, we performed the further optimizations to incorporate the iodine in the 3-position of quinoline **3a**. So, repeated the condition 3, along with 1.5 equiv. of I_2 and found the mixture of **3a**/**4a** in 25% and 35%. Encouraged by the incorporation of 3-iodo and 6-aryldiazo functionalities on the quinoline moiety, we then went on hunting for the best conditions. After systematic studies (entries 4-10, Table 1) we found that when a mixture of 1a and 2a were stirred at rt with 1.5 equiv. of molecular iodine in a closed vessel, the reaction yielded the maximum yield of 3a (67%, entry 7). Approximately 10% of simple 3-iodoquinoline being the by-product.

Table 1. Optimization of the reaction conditions

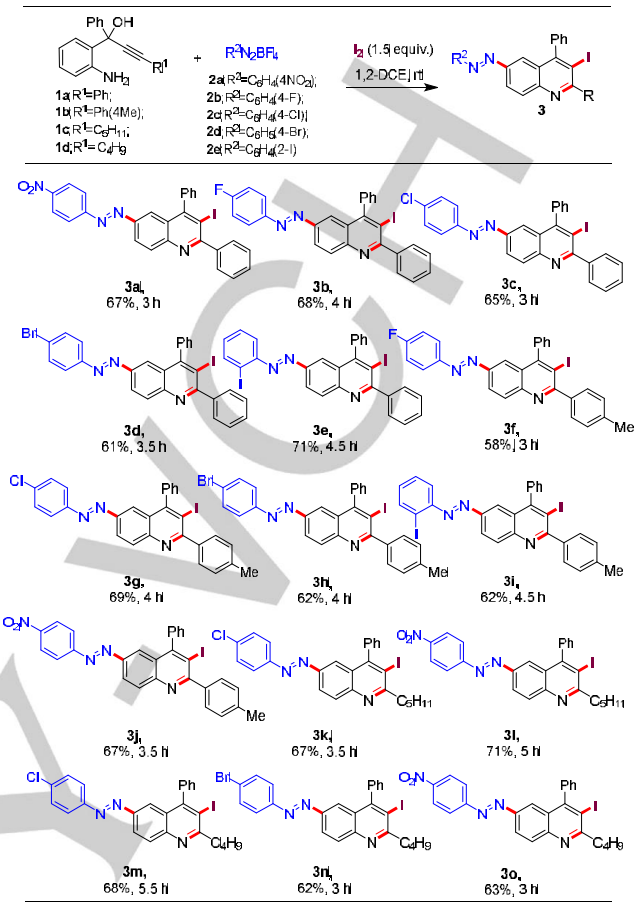


Entry	Reaction conditions	Yield [b]
1	10 mol% $Ca(OTf)_2$/Bu_4NPF_6, neat, 100 °C, 8 h	5% (**4a**)[c]
2	10 mol% $Ca(OTf)_2$/Bu_4NPF_6, DCE, reflux, 2.5 h	35% (**4a**)
3[c]	10 mol% $Ca(OTf)_2$/Bu_4NPF_6, 1,2-DCE, rt, 2.5 h	71% (**4a**)
4	10 mol% $Ca(OTf)_2$/Bu_4NPF_6, I_2 (1.5 equiv), DCE, rt, 3 h	25%/35% (**3a**/**4a**)
5	I_2 (2 equiv.), 1,2-DCE, reflux, 3 h	51% (**3a**)
6	I_2 (2 equiv.), 1,2-DCE, rt, 3 h	67% (**3a**)
7[d]	I_2 (1.5 equiv.), 1,2-DCE, rt, 3 h	67% (**3a**)
8	I_2 (1 equiv.), 1,2-DCE, rt, 3 h	60% (**3a**)
9	I_2 (2 equiv.), EtOAc, rt, 3 h	60% (**3a**)
10	I_2 (2 equiv.), Toluene, rt, 3 h	32% (**3a**)

[a]Mixture of **1a** (1 equiv.), **2a** (1.5 equiv.) were used; [b]Isolated yields; [c]Optimum conditions for 6-diazoquinoline; [d]optimum condition for 3-iodo-6-diazoquinoline; [e]remaining compound isolated as 2,4-diphenylquinoline; DCE: 1,2-dichloroethane; rt: room temperature

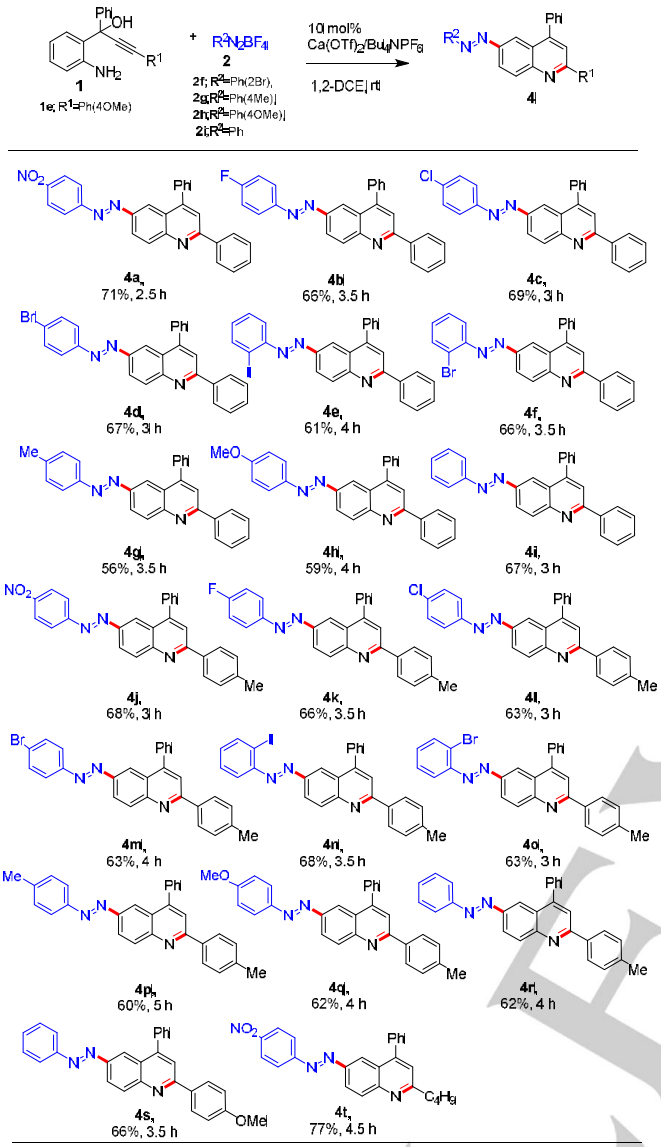
After establishing the optimum condition for the one-pot, azo-coupling and iodocyclization sequence for the synthesis of **3a** (entry-7, Table 1), we were encouraged to check the generality of this reaction. Propargyl alcohol **1a** was treated with a variety of aryl-diazonium salts such as 4-F, 4-Cl, 4-Br, and 2-I under standard iodocyclization conditions and obtained the corresponding 3-iodo-6-aryldiazo quinolines **3b-3e** in moderate to good yields. Similarly, propargyl alcohol **1b** was also reacted to yield the respective quinolines **3f-3j** in good yields. After the satisfactory results obtained with the propargyl alcohols bearing arylalkyne moiety, we then investigated the reactivity of aliphatic alkynes, interestingly, all of them showed similar reactivity in the sequential azocoulping and iodocyclization reaction to furnish the quinolines **3k-3o** in good yields (Table 2).

Table 2. Synthesis of 3-iodo-6-diazo aryl quinolines in one-pot.



During the optimization studies, we observed that in the presence of a Lewis acid catalyst [$Ca(OTf)_2$], **1a** and **2a** reacted to give the quinoline **4a** with 6-aryldizao substitution in 71% yield at room temperature in 2.5 h (Table 1, entry 3). A thorough literature survey suggested us that these kinds of compounds are not made earlier. Hence, we felt that owing to the privileged nature of quinoline moiety and also due to the importance of diazo coupling, these compounds would be useful in material applications and also can fill the space of new chemical entities. Hence we demonstrated the generality of this reaction as shown in Table 3. Propargyl alcohol **1a** reacted with almost nine diazonium salts and furnished the respective diazo-quinolines **4a-4i** in moderate to good yields. Similarly, propargyl alcohol **1b** also yielded the diazoquinolines **4j-4r**. 66% of **4s** was obtained with **1e**, and 77% of **4t** was obtained with aliphatic propargyl alcohols **1d** (Table 3).

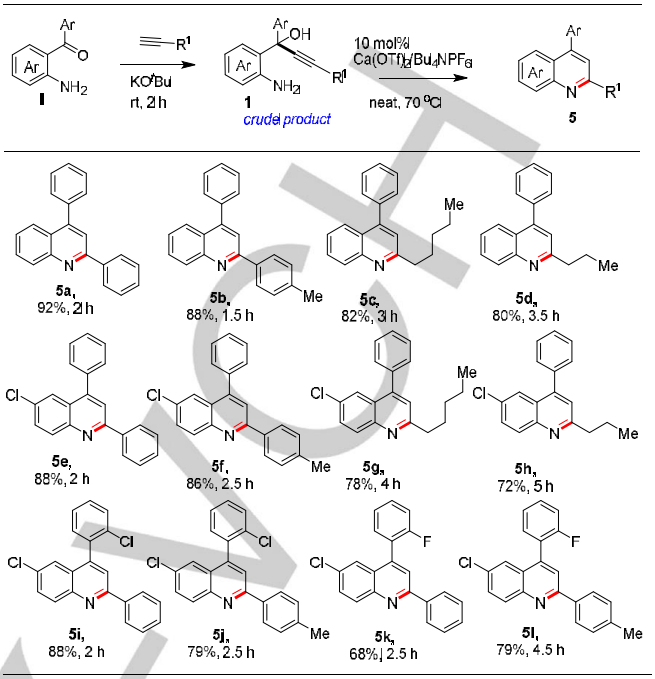
Table 3. Ca(II)-mediated regioselective synthesis of 6-(aryldiazenyl) quinolines.[a)]



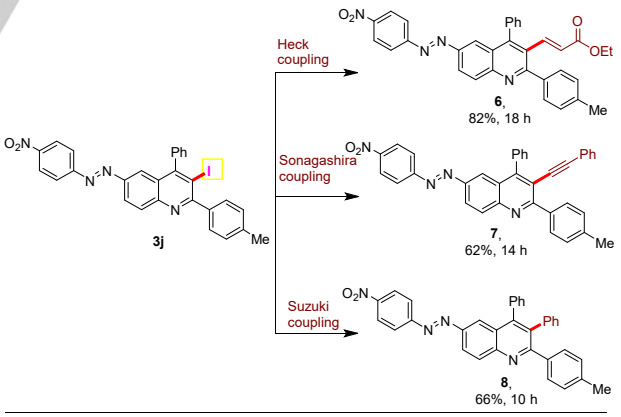
[a)]a mixture of **1** (1 equiv.), **2** (1.5 equiv.) and 10 mol% of $Ca(OTf)_2$/ Bu_4NPF_6 were used.

Finally, we wanted to see the possibility of the intramolecular regioselective cyclization of **1a** with the Ca(II) to yield the quinoline **5a**. Previously, this approach was reported by three groups using different transition metal/Bronsted acid catalysts, such as $CuCl_2$ in methanol[10] 1.5 equiv. of $FeCl_3$ in CH_2Cl_2, [9] and PPTS in MeOH.[7] Hence we felt that it would be useful to develop a catalytic intramolecular cyclization under solvent free conditions from readily available ketones and terminal alkynes instead of 2-aminoaryl propargyl alcohols. Therefore 2-aminoaryl ketones were treated with terminal alkynes and KO^{t}Bu at rt under neat conditions for 2 h, then the crude product was further treated with 10 mol% of $Ca(OTf)_2/Bu_4NPF_6$ for the specified time at 70 °C under neat conditions to obtain the quinolines **5a-5l** in good to excellent yields (Table 4).

Table 4. Synthesis of quinolines by a Ca(II) mediated regioselective cyclization.



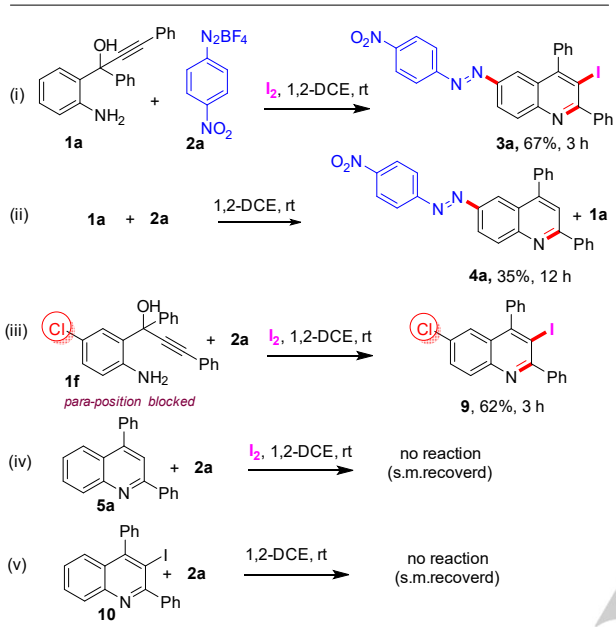
After the discovery of a comprehensive synthetic method for the synthesis of three types of quinolines, namely, 6-aryl diazo-3-iodoquinolines (**3**), 6-(aryldiazenyl)quinolines (**4**) and simple quinolines, we planned to show the synthetic transformations of iodo-quinolines in cross-coupling reactions. Therefore iodide **3j** was treated with ethyl acrylate under Heck reaction[16] conditions to obtain quinoline **6** in 82% yield. Sonagashira coupling[17] between iodide **3j** and phenyl acetylene furnished the quinoline **7** in 62% yield. Suzuki coupling[18] of **3j** with phenyl boronic acid yielded the quinoline **8** in 66% yield.



Scheme 3. Cross coupling reactions of iodide **3j**: Conditions: **Heck**= ethyl acrylate (3 equiv.), $Pd(OAc)_2$ (5 mol%), Bu_4NBr (1 equiv.), Na_2CO_3 (1 equiv.), DMF, 80 °C; **Sonogashira**= Phenylacetylene (2 equiv.), $Pd(OAc)_2$ (2 mol%), DABCO (3 equiv.), MeCN, rt; **Suzuki**= $PhB(OH)_2$ (1.3 equiv.), $Pd(OAc)_2$ (5 mol%), Na_2CO_3 (1 equiv.), DMF/H_2O (2:1), 100 °C.

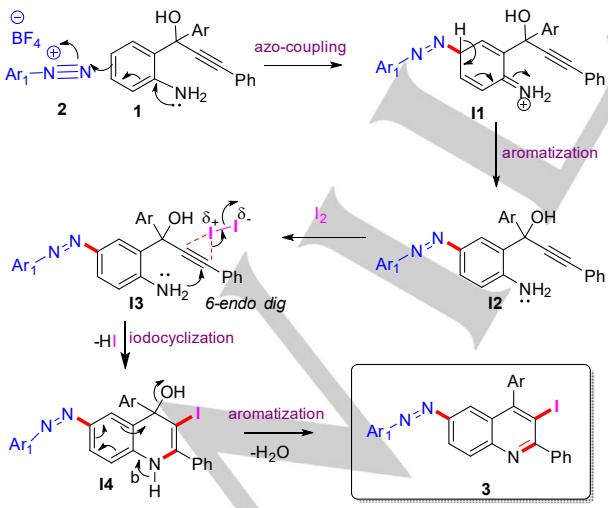
Control experiments were conducted to look at the sequence of the reaction mechanism as shown in the Scheme 4. Under the standard conditions, **1a** and **2a** reacted to give **3a** (equn-i). It is well known that aniline reacts with diazonium salts to give the corresponding azo dyes, so we treated **1a** with **2a** in DCE and surprisingly 35% of 6-diazo arylquinoline **4a** was

formed along with unreacted **1a**. Probably this could be due to the presence of Lewis acidic boron in the form of ArN_2BF_4. When we, blocked the para-position with chloro substitution (**1f**), under standard conditions, reaction yielded 3-iodoquinoline (**9**) without diazotization (equation-iii). Diazotization taking place before cyclization was proved by the condition (iv & v). Quinoline **5a** could not react with either I_2 or ArN_2BF_4 under standard conditions, similar result observed, when 3-iodoquinoline 10 was treated with ArN_2BF_4.



Scheme 4. Control experiments

Based on the observations resulted from the control experiments (Scheme 4), the reaction mechanism for the synthesis of 6-diazoaryl-3-iodo quinoline derivatives (**3**) is described in the Scheme 5. The mechanism starts with the azo-coupling of **1** and **2** followed by the iodocyclization and aromatization sequence as shown in the Scheme 5.



Scheme 5. Mechanism

Conclusion

In conclusion, we have developed a diversity-oriented comprehensive approach for the synthesis of quinoline derivatives from 2-aminoaryl propargyl alcohols. We described the first one-pot, synthesis of 6-aryl diazo-3-iodoquinolines using a sequential azo-coupling followed by electrophilic cyclization. We further extended this study to the synthesis of 6-aryl diazo quinolines and simple quinolines. New structures were confirmed by single-crystal X-ray data. Control experiments authenticated the sequence of the reaction mechanism. The synthetic utility of these compounds in cross-coupling reactions is also demonstrated.

Experimental Section

General information: Unless otherwise noted, all reagents were used as received from commercial suppliers. $Ca(OTf)_2$ and Bu_4NPF_6 were obtained from Sigma-Aldrich and used without further purification. Reactions were performed in flame-dried or oven-dried glassware with magnetic stirring. Reactions were monitored using thin-layer chromatography (TLC) with aluminium sheets silica gel 60 F_{254} from Merck. TLC plates were visualized with UV light (254 nm), iodine treatment or using ninhydrin stain. Column chromatography was carried out using silica gel 60-120 mesh as the stationary phase. NMR spectra were recorded at 500 MHz and 400 MHz (H) and at 125 MHz and 100 MHz (C), respectively on Avance Bruker spectrometer. Chemical shifts (δ) are reported in ppm, using the residual solvent peak in $CDCl_3$ (H: δ = 7.26 and C: δ = 77.0 ppm) as internal standard, and coupling constants (*J*) are given in Hz. Melting points were measured with LABINDIA mepa melting apparatus.

General experimental procedure for the synthesis of 3-iodo-2,4-diphenyl-6-(phenyldiazenyl) quinoline (3a): A mixture of 1-(2-aminophenyl)-1,3-diphenylprop-2-yn-1-ol **1a** (150 mg, 0.50 mmol) and (E)-1-(4-nitrophenyl)-2-(tetrafluoro-l5-boranyl) diazene **2a** (175 mg, 0.75 mmol) stirred in 1,2-dichloroethane (1.5 mL) at room temperature for 15 min then I_2 (194 mg, 0.75 mmol) was added to the reaction mixture and stirred till completion of the reaction (monitored by TLC). After completion of the reaction, the resulting mixture was quenched with aq. saturated solution of $Na_2S_2O_3$ (10 mL) and extracted into dichloromethane (15 mL, thrice). Combined organic layers were washed with brine solution and dried over anhydrous Na_2SO_4, and the solvent was evaporated under reduced pressure, and the residue was purified by column chromatography using EA/PE (5:95, v/v) to obtain the desired product **3a** in 67% yield.

General experimental procedure for the synthesis of 2,4-diphenyl-6-(phenyldiazenyl)quinoline (4a): A mixture of 1-(2-aminophenyl)-1,3-diphenylprop-2-yn-1-ol **1a** (150 mg, 0.50 mmol) and (E)-1-(4-nitrophenyl)-2-(tetrafluoro-l5-boranyl)diazene **2a** (175 mg, 0.75 mmol) stirred in 1,2-dichloroethane (1.5 mL) at room temperature for 30 min then 10 mol% of $Ca(OTf)_2$ and Bu_4NPF_6 were added to the reaction mixture and stirred till completion of the reaction (monitored by TLC). After completion of the reaction, the resulting mixture was quenched with water (10 mL) and extracted into dichloromethane (15 mL, thrice). Combined organic layers were washed with brine solution and dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure and the residue was

purified by column chromatography using EA/PE (5:95, v/v) to obtain the desired product **4a** in 71 % yield.

General experimental procedure for the synthesis of 2,4-diphenylquinoline (5a): Propargylic alcohol 1-(2-aminophenyl)-1,3-diphenylprop-2-yn-1-ol **1a** (150 mg, 0.50 mmol) and 10 mol% of $Ca(OTf)_2$ and Bu_4NPF_6 were stirred at 70 °C under solvent-free condition till completion of the reaction (monitored by TLC). After completion of the reaction, the resulting mixture was quenched with water (10 mL) and extracted into ethyl acetate (15 mL, thrice). Combined organic layers were washed with brine solution and dried over anhydrous Na_2SO_4, and the solvent was evaporated under reduced pressure, and the residue was purified by column chromatography using EA/PE (5:95, v/v) to obtain the desired product **5a** in 92% yield.

Synthesis of ethyl (E)-3-(6-((E)-(4-nitrophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinolin -3-yl)acrylate (6)[8]: Ethyl acrylate (47 mg, 0.47 mmol), was added to a solution of (E)-3-iodo-6-((4-nitrophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline **3j** (115 mg, 0.23 mmol) in DMF (1.8 mL) containing K_2CO_3 (53 mg, 2.5 eq) and Bu_4NBr (50 mg, 1 equiv) and stirred at room temperature for 5 min. $Pd(OAc)_2$ (5 mol %) was then added, and the flask was flushed with N_2, sealed and allowed to stir at 80 °C for 18 h. The resulting mixture was filtered off, washed and extracted with diethyl ether. The combined organics were washed with water and then with brine solution and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the residue was purified by column chromatography with silica gel using EA/PE (7:93, v/v) to give of product **6** in 82% yield.

General experimental procedure synthesis of (E)-6-((4-nitrophenyl)diazenyl) -4-phenyl-3-phenylethynyl) -2-(p-tolyl) quinoline (7)[8]: First $Pd(OAc)_2$ (2 mol%) was dissolved in MeCN (1 mL). Then, the indicated amount of $Pd(OAc)_2$ acetonitrile solution was added to a mixture of alkyne (44.5 mg, 0.45 mmol), aryl halide **3j** (115 mg, 0.22 mmol), DABCO (76 mg, 3 equiv), and MeCN (4 mL). Then the mixture was stirred under N_2 at room temperature for 14 h. The resulting mixture was filtered off, washed and extracted with diethyl ether. The combined organics were washed with water and then with brine solution and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the residue was purified by column chromatography with silica gel using EA/PE (7:93, v/v) to give of product **7** in 62% yield.

General experimental procedure synthesis of (E)-6-((4-nitrophenyl)diazenyl)-3,4-diphenyl-2-(p-tolyl)quinoline (8)[8]: $PhB(OH)_2$ (41.1 mg, 0.33 mmol) was added to a solution of (E)-3-iodo-6-((4-nitrophenyl) diazenyl)-4-phenyl-2-(p-tolyl) quinoline **3j** (140 mg, 0.27 mmol) in 3.0 mL of DMF/H_2O (2:1) containing Na_2CO_3 (27.4 mg, 1 equiv) and stirred at room temperature for 5 min. $Pd(OAc)_2$ (5 mol %) was then added, and the flask was flushed with N_2, sealed and allowed to stir at 100 °C for 10 h. The resulting mixture was filtered off, washed and extracted with diethyl ether. The combined organics were washed with water and then with brine and dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure, and the residue was purified by column chromatography with silica gel using EA/PE (7:93, v/v) to give of product **8** in 66% yield.

E)-3-iodo-6-((4-nitrophenyl)diazenyl)-2,4-diphenylquinoline (3a): Orange solid; (67%); mp 212-214 °C; ^{1}H NMR (400 MHz, $CDCl_3$):δ 8.41 (d, *J* = 8.8 Hz, 2H), 8.35-8.27 (m, 2H), 8.17 (d, *J* = 5.2 Hz, 1H), 8.05 (d, *J* = 8.4 Hz, 2H), 7.74-7.64 (m, 5H), 7.59-7.53 (m, 3H), 7.43 (d, *J* = 6 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 163.8, 156.2, 155.5, 150.3, 148.9, 143.3, 141.5, 131.1, 129.9, 129.8, 129.3, 129.2, 129, 128.1, 127.8, 127.5, 124.8, 124.1, 123.6, 119.9, 99.9 ppm; ESI *m/z* $[M + H]^+$ 557; HRMS (ESI) *m/z* calcd for $C_{27}H_{17}IN_4O_2$ [M + H]$^+$ 557.0474; found 557.0481

(E)-6-((4-fluorophenyl)diazenyl)-3-iodo-2,4-diphenylquinoline (3b): Orange solid; (68%); mp 222-224 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.31 m, 2H), 8.05 (d, *J* = 2 Hz, 1H), 7.96-7.92 (m, 2H), 7.72-7.70 (m, 2H), 7.64-7.62 (m, 3H), 7.54-7.50 (m, 3H), 7.41-7.39 (m, 2H), 7.20 (t, *J* = 8 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.9, 163.4, 163.1, 155.8, 150.4, 148.3, 143.5, 141.7, 130.8, 129.3, 129.2, 129.1, 128.9, 128.8, 128.8, 128.6, 128, 127.9, 127.6, 127.5, 125, 120.4, 116.3, 99.5 ppm; ESI *m/z* $[M + H]^+$ 530; HRMS (ESI) *m/z* calcd for $C_{27}H_{17}FIN_3$ [M + H]$^+$ 530.0529; found 530.0545

(E)-6-((4-chlorophenyl)diazenyl)-3-iodo-2,4-diphenylquinoline (3c): Orange solid; (65%); mp 232-233 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.2□-8.26 (m, 1H), 8.22-8.20 (m, 1H), 8.04 (d, *J* = 2 Hz, 1H), 7.85-7.83 (m, 2H), 7.70-7.68 (m, 2H), 7.64-7.58 (m, 3H), 7.52-7.45 (m, 5H), 7.39-7.36 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.2, 155.9, 150.9, 150.4, 148.4, 143.5, 141.7, 137.4, 130.8, 129.4, 129.3, 129.2, 129.1, 128.9, 128.8, 128.8, 128, 127.6, 124.3, 120.4, 99.6 ppm; ESI *m/z* $[M + H]^+$ 547; Anal. calcd: for $C_{27}H_{17}ClIN_3$: C:59.42; H: 3.14; N: 7.70; found C: 59.48; H: 3.18; N: 7.65.

(E)-6-((4-bromophenyl)diazenyl)-3-iodo-2,4-diphenylquinoline (3d): Orange solid; (61%); mp 198-200 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.31-8.23 (m, 2H), 8.08 (s, 1H), 7.81-7.79 (m, 2H), 7.73-7.53 (m, 10 H), 7.40 (d, *J* = 6.4 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 163.2, 155.9, 151.2, 150.4, 148.4, 143.4, 141.7, 132.4, 130.8, 130.1, 129.3, 129.2, 128.9, 128.7, 128.2, 128.1, 128, 127.6, 127.3, 125.9, 124.5, 120.3, 99.6 ppm; ESI *m/z* $[M + H]^+$ 590; HRMS (ESI) *m/z* calcd for $C_{27}H_{17}BrIN_3$ [M + H]$^+$ 589.9728; found 589.9731

(E)-3-iodo-6-((2-iodophenyl)diazenyl)-2,4-diphenylquinoline (3e): Orange solid; (71%); mp 206-208 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.37 (d, *J* = 4 Hz, 1H), 8.24 (d, *J* = 8.8 Hz, 1H), 8.01 (s, 1H), 7.69 (d, *J* = 6.8 Hz, 2H), 7.61-7.50 (m, 7H), 7.40-7.29 (m, 4H), 7.17-7.14 (m, 1H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ163.2, 155.7, 148.4, 141.7, 140.6, 138.8, 137.3, 130.8, 130, 129.4, 129.2, 129.1, 129.1, 128.8, 128.7, 128.6, 128, 127.1, 126.8, 124.2, 120.2, 99.7, 98.7 ppm; ESI *m/z* $[M + H]^+$ 638; Anal. calcd. for $C_{27}H_{17}I_2N_3$: C: 50.89; H: 2.69; N, 6.59; found C, 50.84; H, 2.68; N, 6.61.

(E)-6-((4-fluorophenyl)diazenyl)-3-iodo-4-phenyl-2-(p-tolyl)quinoline (3f): Orange solid; (58%); mp 230-231 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.31-8.29 (m, 2H), 8.24 , (d, *J* = 8.8 Hz, 2H), 8.07 (d, *J* = 1.6 Hz, 2H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.73-7.62 (m, 5H), 7.55-7.52 (m, 2H), 7.41-7.39 (m, 2H), 2.50 (s, 3H) ppm;^{13}C NMR (100 MHz, $CDCl_3$):δ 163.2, 155.9, 151.2, 150.4, 148.4, 143.5, 141.7, 132.4, 130.8, 129.3, 129.2, 129.1, 128.9, 128.8, 128.6, 128.1, 128, 127.9, 127.6, 125.9, 124.5, 120.3, 99.6, 21.5 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{19}FIN_3$ [M + H]$^+$ 544.0685; found 544.0691

(E)-6-((4-chlorophenyl)diazenyl)-3-iodo-4-phenyl-2-(p-tolyl)quinoline (g): Orange solid; (69%); mp 227-229 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.30-8.28 (m, 1H), 8.23 (d, *J* = 8.5 Hz, 1H), 8.05 (d, *J* = 2 Hz, 1H), 7.87 (d, *J* = 9 Hz, 2H), 7.64-7.62 (m, 4H), 7.58 (s, 1H), 7.49 (d, *J* = 9 Hz, 2H), 7.41-7.39 (m, 2H), 7.33-7.31 (m, 2H), 2.48 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.3, 155.8, 150.9, 150.3, 148.4, 141.8, 140.6, 138.8, 137.3, 130.8, 129.4, 129.3, 129.2, 128.9, 128.7, 128.6, 128, 127.5, 127.1, 126.8, 124.3, 120.3, 99.8, 21.5 ppm; ESI *m/z* [M + H]$^+$ 560; HRMS (ESI) *m/z* calcd for $C_{28}H_{19}ClIN_3$ [M + H]$^+$ 560.0390; found 560.0379

(E)-6-((4-bromophenyl)diazenyl)-3-iodo-4-phenyl-2-(p-tolyl) quinoline (h): Orange solid; (62%); mp 218-220 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.30-8.28 (m, 1H), 8.23 (d, *J* = 8.5 Hz, 1H), 8.06 (d, *J* = 2 Hz, 1H), 7.79 (d, *J* = 9 Hz, 1H), 7.65-7.61 (m, 7H), 7.40-7.34 (m, 5H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.3, 155.8, 151.2, 150.4, 148.4, 141.8, 140.6, 138.8, 132.4, 130.8, 130, 129.3, 129.2, 128.9, 128.7, 128.6, 128.4, 128.1, 127.5, 127.1, 124.5, 120.2, 99.8, 21.5 ppm; ESI *m/z* [M + H]$^+$ 604; HRMS (ESI) *m/z* calcd for $C_{28}H_{19}BrIN_3$ [M + H]$^+$ 603.9885; found 603.9878

(E)-3-iodo-6-((2-iodophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (i): Orange solid; (62%); mp 229-231 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.36-8.33 (m, 1H), 8.22 (d, *J* = 4.8 Hz, 1H), 8.08 (s, 1H), 8 (d, *J* = 8 Hz, 1H), 7.61-7.58 (m, 6H), 7.39-7.31 (m, 5H), 7.14 (d, 6.8 Hz, 1H), 2.43 (s, 3H)^{13}C NMR (100 MHz, $CDCl_3$): δ 163.2, 155.8, 150.9, 150.2, 148.4, 141.7, 140.5, 139.9, 138.7, 132.5, 130.8, 129.9, 129.2, 129.1, 128.8, 128.6, 128.5, 127.8, 127.4, 121.3, 117.1, 103.3, 99.6, 21.4 ppm; ESI *m/z* [M + H]$^+$ 638 Anal. calcd. for $C_{28}H_{19}I_2N_3$: C: 51.64; H: 2.94; N: 6.45; found C, 51.72; H, 2.91; N, 6.39.

(E) 3-iodo-6-((4-nitrophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (j): Orange solid; (67%); mp 208-210 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.39-8.38 (m, 2H), 8.32-8.29 (m, 1H), 8.25 (d, *J* = 9 Hz, 1H), 8.15 (d, *J* = 2 Hz, 1H), 8.04 (d, *J* = 9 Hz, 2H), 7.65-7.62 (m, 5H), 7.41-7.35 (m, 4H), 2.48 (s, 3H) ppm;^{13}C NMR (100 MHz, $CDCl_3$): δ 163.9, 156.1, 155.5, 150.3, 148.9, 141.6, 140.5, 139, 131.1, 129.7, 129.7, 129.6, 129.2, 129.1, 128.9, 128.8, 128.7, 124.7, 123.6, 119.8, 100, 21.5 ppm; ESI *m/z* [M + NH_4]$^+$ 588; HRMS (ESI) *m/z* calcd for $C_{28}H_{19}IN_4O_2$ [M + H]$^+$ 571.0630; found 571.0619

(E)-((4-chlorophenyl)diazenyl)-3-iodo-2-pentyl-4-phenylquinoline (k): Orange solid; (67%); mp 178-180 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23-8.20 (m, 1H), 8.11 (d, *J* = 4.8 Hz, 1H), 7.94 (d, *J* = 2.4 Hz, 1H), 7.82-7.80 (m, 2H), 7.62-7.58 (m, 3H), 7.45-7.43 (m, 2H), 7.30-7.28 (m, 2H), 3.30 (d, *J* = 7.8 Hz, 2H), 1.94-1.89 (m, 2H), 1.54-1.44 (m, 4H), 0.98-0.94 (m, 3H) ppm;^{13}C NMR (125 MHz, $CDCl_3$): δ164.5, 154.9, 150.8, 149.9, 148.4, 141.7, 137.2, 130.1, 129.3, 129.1, 128.7, 128.7, 127.1, 124.2, 119.8, 101, 43.4, 31.8, 28.8, 22.5, 14.1 ppm; ESI *m/z* [M + H]$^+$ 540; HRMS (ESI) *m/z* calcd for $C_{26}H_{23}ClIN_3$ [M + H]$^+$ 540.0703; found 540.0699

(E)-3-iodo-6-((4-nitrophenyl)diazenyl)-2-pentyl-4-phenylquinoline (3l): Orange solid; (71%); mp 190-192 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.37 (d, *J* = 9.2 Hz, 2H), 8.28-8.25 (m, 1H), 8.16 (d, *J* = 9.2 Hz, 1H), 8.07 (d, *J* = 2 Hz, 1H), 8.01 (d, *J* = 9.2 Hz, 2H), 7.64-7.61 (m, 3H), 7.34-7.32 (m, 2H), 3.33 (t, *J* = 7.6 Hz, 2H), 1.95-1.89 (m, 2H), 1.57-1.45 (m, 4H), 1.0-0.97 (m, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 165.3, 155.6, 155.2, 149.9, 148.8, 148.7, 141.6, 130.4, 129.8, 129.1, 128.9, 128.8, 127.1, 124.7, 123.5, 119.4, 101.7, 43.5, 31.9, 28.8, 22.6, 14.1 ppm; ESI *m/z* [M + H]$^+$ 551; Anal. calcd. for $C_{26}H_{23}IN_4O_2$: C: 56.74; H: 4.21; N: 10.18; found C, 56.68; H, 4.94; N, 10.09

(E)-2-butyl-6-((4-chlorophenyl)diazenyl)-3-iodo-4-phenylquinoline (3m): Orange solid; (68%); mp 183-184 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.27-8.24 (m, 1H), 8.14 (d, *J* = 9.2 Hz, 1H), 7.98 (d, *J* = 2 Hz, 1H), 7.85 (d, *J* = 8.4 Hz, 2H), 7.62 (d, *J* = 7.2 Hz, 3H), 7.48 (d, *J* = 8.6 Hz, 2H), 7.31 (d, *J* = 6 Hz, 2H), 3.34 (t, *J* = 8.4 Hz, 2H), 1.93-1.88 (m, 2H), 1.62-1.57 (m, 2H), 1.06 (t, *J* = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.6, 155, 150.8, 149.9, 148.4, 141.7, 137.2, 130.1, 129.4, 129.1, 128.8, 128.7, 128.3, 127.1, 124.2, 119.8, 101.5, 43.3, 31.3, 22.9, 14.1 ppm; ESI *m/z* [M + H]$^+$ 540; HRMS (ESI) *m/z* calcd for $C_{26}H_{23}ClIN_3$ [M + H]$^+$ 540.0703; found 540.0699

(E)-6-((4-bromophenyl)diazenyl)-2-butyl-3-iodo-4-phenylquinoline (3n): Orange solid; (62%); mp 180-182 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.27-8.24 (m, 1H), 8.13 (d, *J* = 5.2 Hz, 1H), 7.98 (d, *J* = 2 Hz, 1H), 7.77 (d, *J* = 8.8 Hz, 2H), 7.64-7.60 (m, 5H), 7.33-7.31 (m, 2H), 3.33 (t, *J* = 8 Hz, 2H), 1.93-1.89 (m, 2H), 1.65-1.56 (m, 2H), 1.05 (t, *J* = 7.6 Hz, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 164.3, 154.7, 150.9, 149.6, 148.1, 141.4, 132.1, 129.8, 128.8, 128.5, 128.4, 128, 126.8, 125.4, 124.1, 119.5, 101.2, 42.9, 31, 22.6, 13.8 ppm; ESI *m/z* [M + NH_4]$^+$ 587; HRMS (ESI) *m/z* calcd for $C_{25}H_{21}BrIN_3$ [M + H]$^+$ 570.0041; found 570.0049

(E)-2-butyl-3-iodo-6-((4-nitrophenyl)diazenyl)-4-phenylquinoline (3o): Orange solid; (63%); mp 191-193 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.28-8.26 (m, 1H), 8.16 (d, *J* = 9.2 Hz, 1H), 8.07 (s, 1H), 8.02 (d, *J* = 8.8 Hz, 2H), 7.63 (d, *J* = 6.4 Hz, 3H), 7.33 (d, *J* = 6.8 Hz, 2H), 3.34 (d, *J* = 7.6 Hz, 2H), 1.94-1.90 (m, 2H), 1.64-1.57 (m, 2H), 1.06 (t, *J* = 7.2 Hz, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.3, 155.6, 149.9, 148.8, 148.7, 141.6, 130.4, 129.8, 129.1, 129, 128.9, 128.8, 127.1, 124.7, 123.5, 119.4, 101.7, 43.3, 31.2, 22.8, 14 ppm; HRMS (ESI) *m/z* calcd for $C_{25}H_{21}IN_4O_2$ [M + H]$^+$ 537.0787; found 537.0793

(E)-6-((4-nitrophenyl)diazenyl)-2,4-diphenylquinoline (4a): Orange solid; (71%); mp 175-176 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.65 (s, 1H), 8.40 (d, *J* = 8 Hz, 2H), 8.33 (d, *J* = 0.5 Hz, 2H, 8.27 (d, *J* = 7.5 Hz, 2H), 8.07 (d, *J* = 9 Hz, 2H), 7.96 (s, 1H), 7.69-7.52 (m, 8H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.6, 155.7, 150.9, 150.7, 150,

148.8, 139.1, 137.8, 131.7, 130, 129.6, 129, 128.9, 128.9, 128.7, 127.7, 126, 124.7, 123.5, 120.1, 119.5 ppm; HRMS (ESI) *m/z* calcd for $C_{27}H_{18}N_4O_2$ $[M+H]^+$ 431.1507; found 431.1512

(E)-6-((4-fluorophenyl)diazenyl)-2,4-diphenylquinoline (4b): Orange solid; (66%); mp 178-181 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.55 (t, *J* = 1.5 Hz, 2H), 8.26-8.25 (m, 2H), 7.93-7.89 (m, 3H), 7.68-7.49 (m, 11H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.1, 151, 150.4, 150.1, 139.2, 137.9, 137.1, 131.5, 129.8, 129.7, 129.6, 129.4, 128.9, 128.8, 128.7, 127.6, 126.9, 126, 124.2, 121.9, 119.9 ppm; HRMS (ESI) *m/z* calcd for $C_{27}H_{18}FN_3$ [M + H]$^+$ 404.1562; found 404.1568

(E)-6-((4-chlorophenyl)diazenyl)-2,4-diphenylquinoline (4c): Pale orange solid; (69%); mp 214-215 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.55 (s, 1H), 8.25-8.31 (m, 1H), 7.89-7.93 (m, 2H), 7.59-7.68 (m, 3H), 7.49-7.57 (m, 11H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.1, 151, 150.5, 150.4, 150, 139.2, 137.9, 137, 131.4, 129.8, 129.6, 129.4, 129.2, 128.9, 128.8, 128.7, 127.7, 126.9, 126, 124.2, 120 ppm; HRMS (ESI) *m/z* calcd for $C_{27}H_{18}ClN_3$ [M + H]$^+$ 420.1278; found 420.1230

(E)-6-((4-bromophenyl)diazenyl)-2,4-diphenylquinoline (4d): Orange solid; (67%); mp 195-196 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.56 (s, 1H), 8.31 (d, *J* = 1.5 Hz, 2H), 8.27-8.25 (m, 2H), 7.93 (s, 1H), 7.83 (d, *J* = 8.8 Hz, 2H), 7.68-7.50 (m, 10H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.1, 151.3, 150.5, 150.4, 150, 139.2, 137.9, 132.4, 131.5, 129.8, 129.6, 129, 128.9, 128.8, 127.7, 127.2, 126, 125.6, 124.4, 120, 119.9 ppm; HRMS (ESI) *m/z* calcd for $C_{27}H_{18}BrN_3$ [M + H]$^+$ 464.0762; found 464.0780

(E)-6-((2-iodophenyl)diazenyl)-2,4-diphenylquinoline (4e): Orange solid; (61%); mp 178-179 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.40 (d, *J* = 2 Hz, 1H), 8.35 (s, 1H), 8.32-7.94 (m, 1H), 7.69-7.63 (m, 2H), 7.61-7.59 (m, 1H), 7.58-7.52 (m, 1H), 7.45-7.41(m, 9H), 7.28 (s, 1H), 7.20-7.16 (m, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ158.2, 151.2, 150.5, 150.5, 149.9, 139.9, 139.2, 137.8, 132.4, 131.5, 129.8, 129.6, 128.9, 128.9, 128.8, 128.7, 127.7, 127.2, 125.9, 120.8, 119.9, 117.2, 103.1 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{18}IN_3$ [M + H]$^+$ 512.0578; found 512.0602

(E)-6-((2-bromophenyl)diazenyl)-2,4-diphenylquinoline (4f): Orange solid; (66%); mp 177-179 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.55 (s, 1H), 8.31 (d, *J* = 0.5 Hz, 2H), 8.25 (d, *J* = 7 Hz, 2H), 7.91 (t, *J* = 9.5 Hz, 3H), 7.68-7.56 (m, 7H), 7.52-7.49 (m, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.1, 151, 150.5, 150.4, 150.1, 139.2, 138, 137.1, 137, 131.5, 129.8, 129.6, 129.4, 128.9, 128.8, 128.7, 127.7, 126.9, 126, 124.2, 120 ppm; HRMS (ESI) *m/z* calcd for $C_{27}H_{18}BrN_3$ [M + H]$^+$ 464.0762; found 464.0750

(E)-2,4-diphenyl-6-(p-tolyldiazenyl)quinoline (4g): Orange solid; (56%); mp 187-189 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.58 (s, 1H), 8.33 (d, *J* = 1.5 Hz, 2H), 8.27-8.25 (m, 2H), 7.93 (s, 1H), 7.65-7.52 (m, 11H), 7.37 (s, 1H), 2.77 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 150.6, 148.3, 147.7, 143.9, 138.5, 131.3, 131.2, 129.8, 129.6, 128.9, 128.8, 128.7, 127.7, 127, 126.6, 126.5, 126.4, 126, 120.3, 119.9, 115.3, 17.5 ppm; HRMS (ESI) *m/z* calcd. for $C_{28}H_{21}N_3$ [M + H]$^+$ 400.1813; found 400.1778

(E)-6-((4-methoxyphenyl)diazenyl)-2,4-diphenylquinoline (4h): Orange solid; (59%); mp 180-182 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.49 (s, 1H), 8.42-8.28 (m, 2H), 7.91-7.97 (m, 2H), 7.64-7.69 (m, 3H), 7.51-7.58 (m, 8H), 7.03 (d, *J* = 9.2 Hz, 2H), 3.92 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 157.7, 151.9, 150.3, 150.2, 150.1, 147.1, 139.4, 138.1, 131.3, 129.6, 129.3, 128.9, 128.8, 128.7, 127.6, 126.1, 125.7, 124.9, 120.2, 119.9, 114.3, 55.6 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{21}N_3O$ [M + H]$^+$416. 1778; found 416.1748

(E)-2,4-diphenyl-6-(phenyldiazenyl)quinoline (4i): Orange solid; (67%); mp 178-179 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.57 (d, *J* =1 Hz, 1H), 8.33 (d, *J* = 2.5 Hz, 2H), 8.27-8.25 (m, 2H), 7.96-7.94 (m, 2H), 7.69-7.49 (m, 12H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.9, 152.7, 150.4, 150.4, 150.2, 139.3, 138, 131.4, 131.1, 129.7, 129.6, 129.1, 128.9, 128.8, 128.7, 127.7, 126.6, 126, 122.9, 120.1, 119.9 ppm; HRMS (ESI) *m/z* calcd. for $C_{27}H_{19}N_3$ [M + H]$^+$ 386.1657; found 386.1666

(E)-6-((4-nitrophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4j): Orange solid; (68%); mp 188-190 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.63 (s, 1H), 8.41-8.38 (m, 2H), 8.31 (d,*J* = 0.8 Hz, 2H), 8.17 (d, *J*= 8.4 Hz, 2H), 8.08-8.05 (m, 2H), 7.94 (s, 1H), 7.68-7.60 (m, 5H), 7.38 (d, *J* = 8 Hz, 2H), 2.48 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.1, 151.1, 150.5, 150.3, 149.9, 140, 138.1, 137, 136.4, 131.4, 129.7, 129.6, 129.4, 128.8, 128.7, 127.5, 126.9, 125.9, 124.2, 119.9, 119.8, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}N_4O_2$ [M + H]$^+$ 445.1664; found 445.1676

(E)-6-((4-fluorophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4k): Orange solid; (66%); mp 199-201 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.53 (s, 1H), 8.29 (d, *J* = 1.6 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 7.98-7.95 (m, 2H), 7.90 (s, 1H), 7.68-7.58 (m, 6H), 7.37 (t, *J* = 8.8 Hz, 2H), 7.36 (s, 2H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.9, 150.3, 150.2, 149.9, 149.2, 149.1, 140, 138.1, 136.4, 131.3, 129.7, 129.7, 129.6, 128.8, 128.7, 127.5, 126.7, 125.9, 125, 124.9, 119.9, 119.7, 116.2, 115.9, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}FN_3$ [M + H]$^+$ 418.1719; found 418.1728

(E)-6-((4-chlorophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4l): Pale orange solid; (63%); mp 191-192 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.54 (s, 1H), 8.30 (d, *J* = 1Hz, 2H), 7.89-8.17 (m, 2H), 7.67-7.64 (m, 3H), 7.62-7.58 (m, 5H), 7.51-7.41 (m, 2H), 7.38-7.28 (m, 2H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.1, 151.1, 150.4, 150.3, 149.9, 139.9, 138.1, 137, 136.4, 131.4, 129.6, 129.6, 129.3, 128.8, 128.7, 127.5, 126.9, 125.9, 124.1, 119.8, 119.7, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}ClN_3$ [M + H]$^+$ 434.1778; found 434.1382

(E)-6-((4-bromophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4m): Orange solid; (63%); mp 215-216 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.54 (s, 1H), 8.29 (s, 2H), 8.16 (d, *J* = 8 Hz, 2H), 7.9 (s, 1H), 7.82 (d, *J* = 8.8 Hz, 2H), 7.66-7.58 (m, 7H), 7.37 (d, *J* = 8 Hz, 2H), 2.47 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.1, 151.4, 150.5, 150.3, 149.9, 140, 138, 136.4, 132.4, 131.4, 129.7, 129.6, 128.9, 128.7, 127.6, 127.2, 125.9, 125.5, 124.4, 119.8, 119.7, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}BrN_3$ [M + H]$^+$ 478.0918; found 478.0927

(E)-6-((2-iodophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4n): Orange solid; (68%); mp 290-291 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.30 (s, 1H), 8.17 (d, *J* = 8.4 Hz, 1H), 8.07-8.04 (m, 1H), 7.92 (s, 2H), 7.69-7.65 (m, 1H), 7.64 (d, *J* = 1.6 Hz, 1H), 7.62-7.57 (m, 6H), 7.45-7.37 (m, 3H), 7.20-7.16 (m, 1H), 2.47 (s, 3H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.1, 151.2, 150.5, 150.4, 149.8, 140.1, 139.9, 137.9, 136.3, 132.3, 131.4, 129.7, 129.6, 128.9, 128.8, 128.7, 127.5, 127.2, 125.8, 120.7, 119.7, 117.2, 103.1, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}IN_3$ [M + H]$^+$ 526.0778; found 526.0785

(E)-6-((2-bromophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinoline (4o): Pale orange solid; (63%); mp 155-156 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.61 (d, *J* = 2 Hz, 1H), 8.38-8.36 (m, 1H), 8.30 (d, *J* = 9 Hz, 1H), 8.17 (d, *J* = 3.5 Hz, 2H), 7.91-7.77 (m, 1H), 7.71-7.68 (m, 1H), 7.67-7.58 (m, 7H), 7.37 (d, *J* = 8 Hz, 3H), 2.47 (s, 3H) ppm;^{13}C NMR (125 MHz, $CDCl_3$): δ 158.1, 150.6, 150.3, 150.2, 149.6, 140, 137.9, 136.4, 133.8, 131.9, 131.4, 129.6, 129.6, 129.6, 129.6, 128.8, 128.7, 128.6, 127.9, 127.6, 127.5, 127.5, 126.1, 125.8, 120.2, 119.7, 117.6, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{20}BrN_3$ [M + H]$^+$ 478.0878 ; found 478.0919

(E)-4-phenyl-2-(p-tolyl)-6-(p-tolyldiazenyl)quinoline (4p): Orange solid; (60%); mp 165-166 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.58-8.57 (m, 1H), 8.31 (d, *J* = 1.2 Hz, 2H), 8.18-8.16 (m, 2H), 7.91 (s, 1H), 7.68-7.58 (m, 7H), 7.39-7.37 (m, 4H), 2.77 (s, 3H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.8, 150.7, 150.5, 150.4, 150.1, 140, 138.5, 138, 136.3, 131.3, 131.1, 129.7, 129.6, 128.8, 128.7, 128.6, 127.5, 126.8, 126.4, 125.9, 120.1, 119.7, 115.2, 21.4, 17.6 ppm; HRMS (ESI) *m/z* calcd for $C_{29}H_{23}N_3$ [M + H]$^+$ 414.1970; found 414.1961

(E)-4-phenyl-6-(4-methoxyphenyldiazenyl)-2-(p-tolyl)quinoline (4q) : Orange solid; (62%); mp 181-182 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.48 (d, *J* = 1 Hz, 1H), 8.31-8.30 (m, 2H), 8.16 (d, *J* = 8.5 Hz, 2H), 7.96-7.89 (m, 2H), 7.67-7.62 (m, 1H), 7.60-7.57 (m, 5H), 7.38-7.37 (m, *J* = 8 Hz, 2H), 7.03 (m, *J* = 9 Hz, 2H), 3.91 (s, 3H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 162.2, 157.5, 150.3, 147.1, 139.9, 138.9, 138.2, 131.1, 129.7, 129.6, 128.8, 128.7, 128.6, 128.6, 127.5, 126, 125.6, 124.8, 120.3, 119.6, 114.3, 55.6, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{29}H_{23}N_3O$ [M + H]$^+$ 430.1878; found 430.1900

(E)-4-phenyl-6-(phenyldiazenyl)-2-(p-tolyl)quinoline (4r): Orange solid; (62%); mp 191-192 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.32 (s, 1H), 8.17 (d, *J* = 8 Hz, 2H), 7.96-7.91 (m, 2H), 7.68-7.58 (m, 3H), 7.55-7.49 (m, 8H), 7.38 (d, *J* = 8Hz, 2H), 2.47 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ157.9, 152.7, 150.3, 150.3, 150.1, 139.9, 138.1, 136.4, 131.3, 131.1, 129.6, 129.1, 129, 128.8, 128.6, 127.5, 127.4, 126.5, 125.9, 122.8, 120.4, 120.1, 119.7, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{21}N_3$ [M+H]$^+$ 400.1778; found 400.1789

(E)-2-(4-methoxyphenyl)-4-phenyl-6-(phenyldiazenyl)quinoline (4s): Orange solid; (66%); mp 187-189 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.40 (d, *J* = 4.8 Hz, 2H), 8.35-8.31 (m, 2H), 8.28 (d, *J* = 6.8 Hz, 2H), 8.18-8.05 (m, 2H), 7.74-7.65 (m, 5H), 7.59-7.53 (m, 3H), 7.43 (d, *J* = 6 Hz, 2H), 3.88 (s, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.8, 156.1, 155.5, 150.3, 148.9, 148.8, 143.3, 141.5, 131, 129.9, 129.6, 129.2, 129, 128.8, 128, 127.8, 127.5, 124.8, 124.1, 123.6, 119.9, 53.6 ppm; HRMS (ESI) *m/z* calcd for $C_{28}H_{21}N_3O$ [M + H]$^+$ 416. 1778; found 416.1737

(E)-2-butyl-6-((4-nitrophenyl)diazenyl)-4-phenylquinoline (4t): Orange solid; (77%); mp 160-162 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.62 (d, *J* = 2Hz, 1H), 8.39 (d, *J* = 9 Hz, 2H), 8.30-8.27 (m, 1H), 8.20 (d, *J* = 9 Hz, 1H), 8.05 (d, *J* = 9 Hz, 2H), 7.62-7.58 (m, 5H), 7.38 (s, 1H), 3.07 (t, *J* = 7.8 Hz, 2H), 1.92-7.86 (m, 2H), 1.54-1.50 (m, 2H), 1.01 (t, *J* = 8.8 Hz, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 165, 155.7, 150.5, 150, 149.7, 148.7, 137.6, 130.9, 129.6, 128.8, 128.7, 125.5, 124.7, 123.5, 122.6, 119.2, 39.3, 32.1, 22.8, 14 ppm; HRMS (ESI) *m/z* calcd for $C_{25}H_{22}N_4O_2$ [M + H]$^+$ 411.1820; found 411.1828

4-phenyl-2-propylquinoline (5d): Colourless liquid; (80%); ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.15 (d, *J* = 8.5 Hz, 1H), 7.90-7.89 (m, 1H), 7.73-7.69 (m, 1H), 7.55-7.49 (m, 5H), 7.47-7.44 (m, 1H), 7.27 (s, 1H), 3.03-3.00 (m, 2H), 1.94-1.90 (m, 2H), 1.08 (t, *J* = 7 Hz, 3H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$): δ 162.4, 148.5, 148.4, 138.3, 129.2, 129.2, 129.1, 128.3, 128.1, 125.7, 125.6, 125.3, 121.6, 41.3, 23.3, 14.1 ppm; HRMS (ESI) *m/z* calcd for $C_{18}H_{17}N$ [M + H]$^+$ 248.1439; found 248.1451

Ethyl (E)-3-(6-((E)-(4-nitrophenyl)diazenyl)-4-phenyl-2-(p-tolyl)quinolin-3-yl)acrylate (6): Orange solid; (82%); mp 256-258 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.37 (d, *J* = 8.4 Hz, 2H), 8.27 (d, *J* = 6.8 Hz, 2H), 8.02 (d, *J* = 8.4 Hz, 2H), 7.60-7.58 (m, 6H), 7.38 (d, *J* = 6.8 Hz, 2H), 7.30 (d, *J* = 7.6 Hz, 2H), 4.48 (d, *J* = 16 Hz, 1H), 4.10-4.05 (m, 2H), 2.43 (s, 3H), 1.18 (t, *J* = 7.2 Hz, 3H) ppm;^{13}C NMR (125 MHz, $CDCl_3$): δ 166, 160.9, 155.6, 150.1, 149.8, 149.2, 148.8, 141.3, 139.2, 137.1, 135.7, 131.2, 129.8, 129.7, 129.2, 129, 128.8, 126.8, 126.6, 126, 124.7, 123.5, 119.8, 60.4, 21.4, 14.1 ppm; HRMS (ESI) *m/z* calcd for $C_{33}H_{26}N_4O_4$ [M + H]$^+$ 543.2032; found 543.2022

(E)-6-((4-nitrophenyl)diazenyl)-4-phenyl-3-(phenylethynyl)-2-(p-tolyl)quinoline (7): Orange solid; (62%); mp 261-263 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37-7.28 (m, 2H), 7.24 (d, *J* = 9.2Hz, 1H), 8.15-8.13 (m, 1H), 8.02-7.92 (m, 1H), 7.80 (d, *J* = 7.6 Hz, 2H), 7.71-7.49 (m, 11H), 7.40-7.34 (m, 3H), 2.48 (s, 3H) ppm;^{13}C NMR (125 MHz, $CDCl_3$): δ 156.1, 155.5, 15.4, 148.9, 148.8, 143.3, 141.5, 131.3, 131.1, 129.9, 129.6, 129.1, 128.9, 128.8, 128.7, 128.1, 127.8, 127.5, 127, 124.8, 124.7, 124, 123.6, 120, 116.6, 85.9, 77.5, 21.4 ppm; HRMS (ESI) *m/z* calcd for $C_{36}H_{24}N_4O_2$ [M + H]$^+$ 545.1977 found 545.1971

(E)-6-((4-nitrophenyl)diazenyl)-3,4-diphenyl-2-(p-tolyl)quinoline (8): Orange solid; (66%); mp 230-232 °C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.46-8.43 (m, 1H), 8.39-8.32 (m, 4H), 8.22 (d, *J* = 8 Hz, 4H), 8.12-8.10 (m, 4H), 7.99 (d, *J* = 3.2 Hz, 1H), 7.71-7.65 (m, 5H), 7.44-7.38 (m, 3H), 7.32-7.28 (m, 3H), 2.53 (s, 3H) ppm;^{13}C NMR (125 MHz, $CDCl_3$): δ 158.6, 155.8, 150.9, 150.6, 149.9, 148.7, 147.9, 147.3, 140.3, 137.8, 136.2, 131.6, 129.7, 129.6, 128.9, 128.8, 128.4, 127.6, 126.9, 126, 125.9, 124.8, 123.5, 120, 119.4, 21.5 ppm; ESI *m/z* [M + H]$^+$ 521; HRMS (ESI) *m/z* calcd for $C_{34}H_{24}N_4O_2$ [M + H]$^+$ 521.1977 found 521.1991

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References

1. a) A. A. Joshi, C. L. Vishwanathan, *Bioorg. Med. Chem. Lett.* **2006**, *16*, 2613; b) C. Portela, C. M. M. Afonso, M. M. Pinta, M. J. Ramos, *Bioorg. Med. Chem.* **2004**, *12*, 3313; c) S. W. Elmore, M. J. Coghlan, D. D. Anderson, J. K. Pratt, B. E. Green, A. X. Wang, M. A. Stashko, C. W. Lin, C. M. Tyree, J. N. Miner, P. B. Jacobson, D. M. Wilcox, B. C. Lane, *J. Med. Chem.* **2001**, *44*, 4481; d) O. Billker, V. Lindo, M. Panico, A. E.Etienne, T. Paxton, A. Dell, M. Rogers, R. E. Sinden, H. R. Morris, *Nature* **1998**, *392*, 289; e) W. Peczynskaczoch, F. Pognan, L. Kaczmarek, J. Boratynski, *J. Med. Chem.* **1994**, *37*, 3503; f) R.Musiol, J. Jampilek, K. Kralova, D. R. Richardson, D. Kalinowski, B. Podeszwa, J. Finster, H. Niedbala, A. Palka, J. Polanski, *Bioorg. Med. Chem.* **2007**, *15*, 1280; g) K. Kaur, M. Jain, R. P. Reddy, R. Jain, *Eur. J. Med. Chem.* **2010**, *45*, 3245; h) F. Hayat, E. Moseley, A. Salahuddin, R. L. V. Zyl, A. Azam, *Eur. J. Med. Chem.* **2011**, *46*, 1897.
2. a) M. M. Biddle, M. Lin, K. A. Scheidt, *J. Am. Chem. Soc.* **2007**, *129*, 3830; b) Y. Zhang, M. S. Sigman, *J. Am. Chem. Soc.* **2007**, *129*, 3076; c) B. Tan, Z. Shi, P. J. Chua, G. Zhong, *Org. Lett.* **2008**, *10*, 3425.
3. a) G. A. Ramann, B. J. Cowen, *Molecules*, **2016**, *21*, 986; b) S. M. Prajapati, K. D. Patel, R. H. Vekariya, S. N. Panchal, H. D. Patel, *RSC Adv.,* **2014**, *4*, 24463; c) S. Madapa, A. Tusi, S. Batra, *Curr. Org. Chem.* **2008**, *12*, 1116; d) J. Marco-Contelles, E. Perez-Mayoral, A. Samadi, M. C. Carreiras, E. Soriano, *Chem. Rev*. **2009**, *109*, 2652; Selected recent syntheses: e) Y. Matsubara, S. Hirakawa, Y. Yamaguchi, Z.-I. Yoshida, *Angew. Chem., Int. Ed*. **2011**, *50*, 7670; f) H. Batchu, S. Bhattacharyya, S. Batra, *Org. Lett.* **2012**, *14,* 6330; g) X. Zhang, B. Liu, X. Shu, Y. Gao, H. Lv, J. Zhu, *J. Org. Chem.* **2012**, *77*, 501; h) X. Ji, H. Huang, Y. Li, H. Chen, H. Jiang, *Angew. Chem., Int. Ed.* **2012**, *51*, 7292; i) R. Yan, X. Liu, C. Pan, X. Zhou, X. Li, X. Kang, G. Huang, *Org. Lett.* **2013**, *15*, 4876; j) Y. Wang, C. Chen, J. Peng, M. Li, *Angew. Chem., Int. Ed.* **2013**, *52,* 5323; k) L. Zheng, B. Guo, R. Hua, *J. Org. Chem.* **2014**, *79*, 11541; l) K. Wu, Z. Huang, C. Liu, H. Zhang, A. Lei, *Chem. Commun.* **2015**, *51*, 2286.
4. a) R. Halim, L. Aurelio, P. J. Scammells, B. L. Flynn, *J. Org. Chem.* **2013**, *78*, 4708; b) A. C. Mantovani, T. A. C. Goulart, D. F. Back, P. H. Menezes, G. Zeni, *J. Org. Chem.* **2014**, *79*, 10526; c) M. S. Reddy, N. Thirupathi, Y. K. Kumar, *RSC Adv.* **2012**, *2*, 3986; d) S. Ali, H.-T. Zhu, X.-F. Xia, K.-G. Ji, Y.-F. Yang, X.-R. Song, Y.-M. Liang, *Org. Lett.* **2011**, *13*, 2598; e) Z. Huo, I. D. Gridnev, Y. Yamamoto, *J. Org. Chem.* **2010**, *75*, 1266; f) K. O. Hessian, B. L. Flynn, *Org. Lett.* **2006**, *8*, 243; f) N. Thirupathi, S. Puri, Nuligonda, B. Sridhar, M. S. Reddy, *Adv. Synth. Catal.* **2015**, *358*, 303.
5. K. O. Hessian, B. L. Flynn, *Org. Lett.* **2006**, *8*, 243.
6. S. Ali, H.-T. Zhu, X.-F. Xia, K.-G. Ji, Y.-F. Yang, X.-R. Song, Y.-M. Liang, *Org. Lett.* **2011,** *13*, 2598.
7. M. S. Reddy, N. Thirupathi, Y. K. Kumar, *RSC Adv.* **2012,** *2*, 3986.
8. S. Yaragorla, A. Pareek, R. Dada, P. L. Saini, Eur. *J. Org. Chem.* **2017**, 4600.
9. A. L. Stein, A. R. Rosario, G. Zeni, *Eur. J. Org. Chem.* **2015**, 5640.
10. B. Gabriele, R. Mancuso, G. Salerno, G. Ruffolo, P. Plastina, *J. Org. Chem.* **2007**, *72*, 6873.
11. B. Gabriele, R. Mancuso, E. Lupinacci, R. Spina, G. Salerno, L. Veltri, A. Dibenedetto *Tetrahedron* **2009**, *65*, 8507.
12. a) G. Singh, S. Yaragorla, *RSC Adv.* **2017,** *7*, 18874; b) S. Yaragorla, R. Dada, G. Singh, *Synlett.* **2016**, *27*, 912.
13. H. Wang, Q. Xu, S. Shen, S. Yu, *J. Org. Chem.* **2017**, *82*, 770.
14. B.K. Kerzhner, V. I. Kofanov, T. L. Vrubel, *J. Liq. Chrom.* **1988**, *11*, 3091.
15. a) A. Pareek, R. Dada, M. Rana, A. K. Sharma, S. Yaragorla, *RSC Adv*. **2016**, *6*, 89732; b) S. Yaragorla, A. Pareek, R. Dada, *Adv. Synth. Catal.* **2017,** *359,* 3068; c) S. Yaragorla, A. Pareek, R. Dada, *Tetrahedron Lett*. **2017**, *58*, 4642.
16. Heck coupling see: a) R. F. Heck, *Palladium Reagents in Organic Synthesis*; Academic Press: San Diego, CA, **1985**; pp 276-287; b) G. T. Crisp, *Chem. Soc. Rev.***1998**, *27*, 427; c) S. Brase, A. D. Meijere, *Metal-Catalyzed Cross-Coupling Reactions*; Diederich, F., Stang, P. J., Eds.; Wiley-VCH: Weinheim, Germany, **1998**; p 99.
17. Sonogashira coupling see: K. Sonogashira, Y. Tohda, N. Hagihara, *Tetrahedron Lett*. **1975**, *16*, 4467.
18. Suzuki coupling see: a) A. Suzuki, *J. Organomet. Chem.* **1999**, *576*, 147; b) A. Suzuki, *Metal-Catalyzed Cross-Coupling Reactions*; Diederich, F., Stang, P. J., Eds.; Wiley-VCH: Weinheim, Germany, **1998**; 49; c) N. Miyaura, *Chem. Rev.* **1995**, *95*, 2457.

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FULL PAPER

Srinivasarao Yaragorla* and Abhishek Pareek

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Electrophilic cyclization of 2-Aminophenylprop-1-yn-3-ols to 3-Iodo-6-(aryldiazenyl)quinolines in a one-pot, Azo-coupling and Iodo-cyclization sequence