EurJOC European Journal of Organic Chemistry

FULL PAPER

DOI: 10.1002/ejoc.201500939

Synthetic Studies on Indolocarbazoles: A Facile Synthesis of Staurosporinone Analogues

Potharaju Raju,[a] Ganesan Gobi Rajeshwaran,[a] and Arasambattu K. Mohanakrishnan*[a]

Keywords: Synthetic methods / Natural products / Nitrogen heterocycles / Cyclization / Insertion / Staurosporinone

Synthesis of indolocarbazoles was achieved through thermal electrocyclization followed by triethyl phosphite-mediated nitrene insertion reactions. Total synthesis of staurosporinone analogues was achieved from commercially available 2-methylindole. The CDK5/p25 kinase inhibition potential of some representative staurosporinone analogues was explored by using the TRFRET kinase assay.

Introduction

The chemistry of indolo[2,3-*a*]carbazoles obtained from either soil organisms or marine sources, have been widely explored because of their promising antifungal, antimicrobial, antitumor, and antihypertensive activities.[1] Omura and co-workers reported the first isolation and discovery of staurosporine (**1**; Figure 1), a metabolite from *Streptomyces staurosporeus*, as a highly potent protein kinase C (PKC) inhibitor with an IC_{50} value of 2.7 nM.[2] Staurosporine is also known to inhibit cyclin B/CDK1 enzymes.[3] Thus, staurosporine (**1**) has become the lead structure for the development of new PKC inhibitors. In general, indolocarbazole analogues displayed antitumor properties against different human cancer cell lines[4] and acted as chemotherapeutics against Alzheimer's disease,[5] and other neurodegenerative disorders.[6]

In particular, staurosporine analogues **2** and **3** have high affinity for PKC and also showed prominent cytotoxicity against various human cancer cell lines.[7] The other most important indolo[2,3-*a*]carbazole alkaloid, rebeccamycin (**4**) exhibited topoisomerase I inhibitory activity.[8] Staurosporinone (**5**) has cytotoxic and antimicrobial properties, and inhibits protein kinase C and platelet aggregation.[9] Gö 6976 (**6**), a non-glycosidic indolo[2,3-*a*]carbazole, shows selective inhibition of protein kinase C and acts as an antagonist of HIV-1.[10] Arcyriaflavins A-D **7** showed moderate antibiotic and antifungal activities. Arcyriaflavin C displayed nanomolar-range cell-cycle inhibition effects at the G1 and G2/M stages.[11] Over the years, a plethora of indolocarbazole analogues that contain halogen and methoxy substituents on the benzene portion have been synthesized and explored as a new class of D1/CDK4 and JAK3 inhibitors.[12] Isomeric indolo[3,2-*a*]carbazole alkaloids, asteropusazole A (**8**) and asteropusazole B (**9**; Figure 1) isolated from marine sponges,[13] displayed moderate cytotoxicity and antimicrobial activity. Recently, indolo[2,3-*a*]carbazole analogues have also been explored for optical and solar-cell applications.[14]

The PKC and cyclin-dependent kinase inhibitory activities of indolo[2,3-*a*]carbazoles prompted chemists to develop elegant strategies for the synthesis of these alkaloids.[1,12,15] In most of the synthetic protocols outlined, electrocyclization reaction of bisindolylmaleimides under photochemical conditions has been utilized as a key step.[16] The facile transformation of bisindolylmaleimides into indolo[2,3-*a*]carbazoles was also achieved through oxidative cyclization reactions that involved a Pd catalyst,[17] 2,3-dichloro-5,6-dicyano-1,4-benzoquinone,[18] and phenyliodine bis(trifluoroacetate).[19] The synthesis of indolo[2,3-*a*]-carbazoles has also been accomplished through carbene[20] and nitrene[21] insertion reactions, and ring-closing metathesis.[22] The Diels–Alder reaction of 2,2′-biindoles and their bridged analogues with maleimides have been employed for the synthesis of indolo[2,3-*a*]carbazoles.[23] The Fischer-indolization protocol was also utilized for the synthesis of indolo[2,3-*a*]carbazoles.[24] Recently, Orito and co-workers achieved the synthesis of staurosporinone by Pd-catalyzed carbonylation reaction of 5-aminomethyl indolo[2,3-*a*]carbazole.[25] Most of the indolocarbazoles that exhibit potent biological activities have substituents on the benzene portion of the core. Despite several synthetic protocols available for indolocarbazoles, a flexible and efficient route for the synthesis of unsymmetrical indolo[2,3-*a*]carbazole is still in demand. We recently reported our preliminary results on the synthesis of indolocarbazoles that involve a thermal electrocyclization reaction as a key step.[26] We report herein the full details of the synthesis and CDK5/p25

[a] Department of Organic Chemistry, University of Madras, Guindy Campus, Chennai 600025, Tamil Nadu, India
E-mail: mohan_67@hotmail.com
mohanakrishnan@unom.ac.in
http://www.unom.ac.in

Supporting Information for this article is available on the WWW under http://dx.doi.org/10.1002/ejoc.201500939.

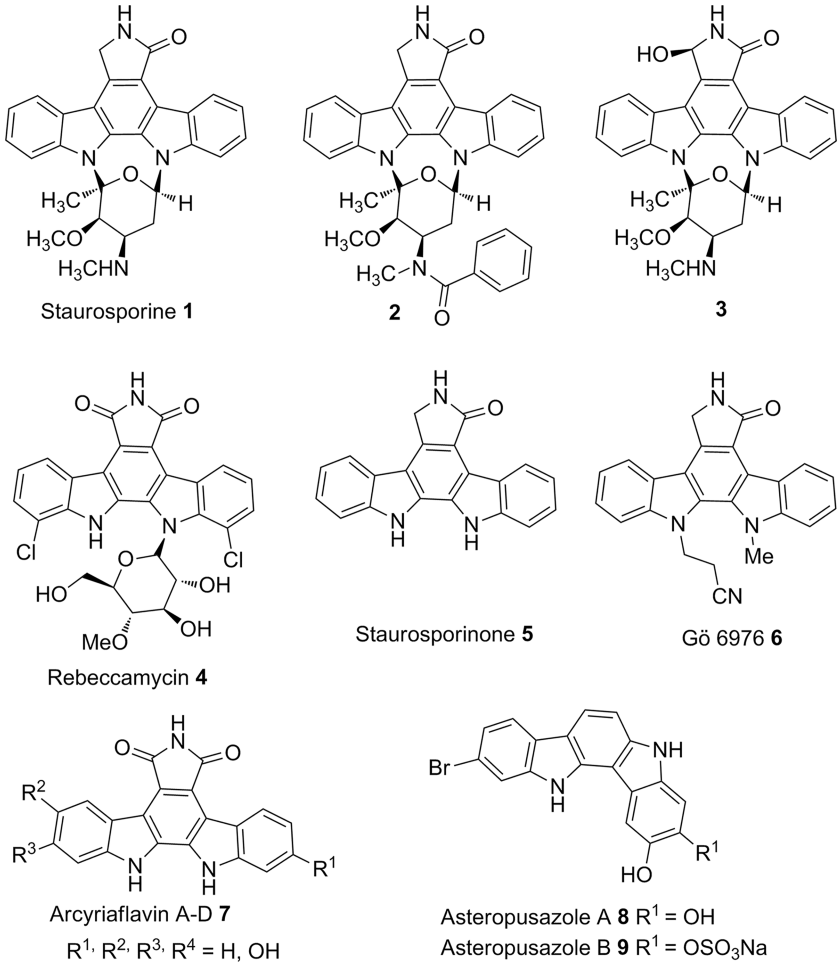
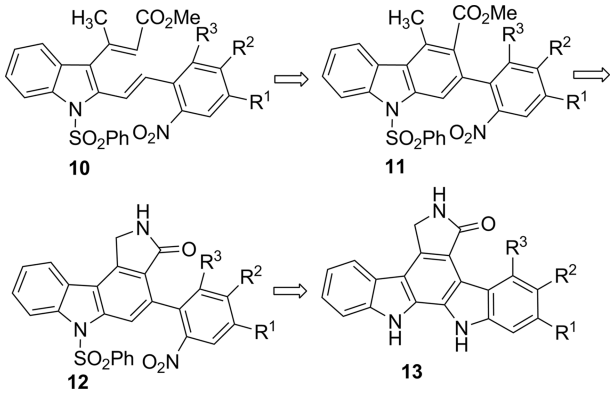


Figure 1. Structures of biologically important indolocarbazoles.

kinase inhibition studies of staurosporinone analogues. Synthesis of staurosporinone **13** was visualized by thermal electrocyclization reaction[27] of 1-(phenylsulfonyl)-2,3-divinylindole (**10**) followed by allylic bromination and amidation to give carbazole **12**. 2′-Nitroarylcarbazole (**12**), upon triethyl phosphite-mediated nitrene insertion followed by subsequent cleavage of the phenylsulfonyl group, may afford target compound **13** (Scheme 1).

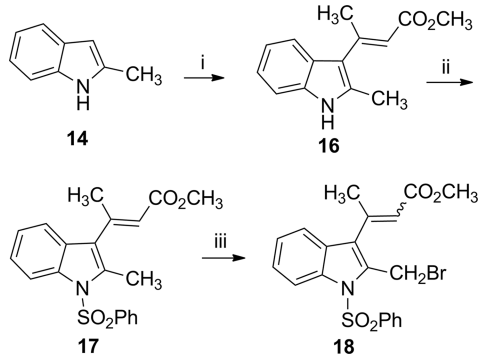


Scheme 1. Schematic pathway for staurosporine aglycon.

Results and Discussion

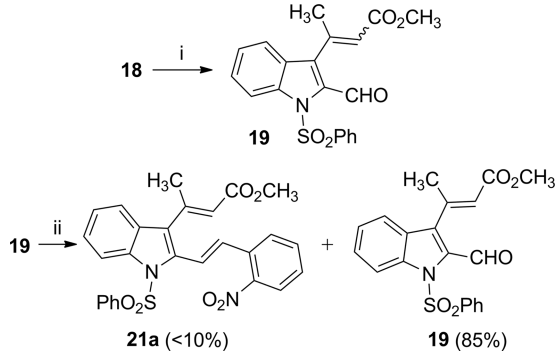
The study began with preparation of required 2,3-divinyl indole **10**. The reaction of 2-methylindole (**14**) with methyl acetoacetate (**15**) in the presence of $FeCl_3$ (20 mol-%) in accordance with the published procedure[28] furnished 2-methyl-3-vinylindole (**16**) as a colorless solid in 93% yield. The phenylsulfonylation of vinylindole **16** under phase-transfer catalytic conditions[29] gave expected 1-(phenylsulfonyl)indole **17** in good yield. Preferential allylic bromination of **17** with *N*-bromosuccinimide (NBS; 1.1 equiv.) in the presence of a catalytic amount of 2,2-azo-bisisobutyronitrile (AIBN) in CCl_4 at reflux temperatures led to the isolation of bromo compound **18** as a mixture of *E* and *Z* isomers (Scheme 2). Pleasingly, the indolyl-2-methyl position was selectively brominated, which was confirmed by ^1H NMR spectroscopy.

Upon oxidation of bromo compound **18** with bis(tetrabutylammonium) dichromate[30] in dry $CHCl_3$ at reflux temperatures for 4 h, followed by workup, afforded aldehyde **19** in 90% yield. Unfortunately, the expected Wittig–Horner reaction of 3-vinyl-indole-2-carboxaldehyde (**19**) with diethyl 2-nitrobenzyl phosphonate (**20**) with NaH as a base in dry tetrahydrofuran (THF) at room temperature led



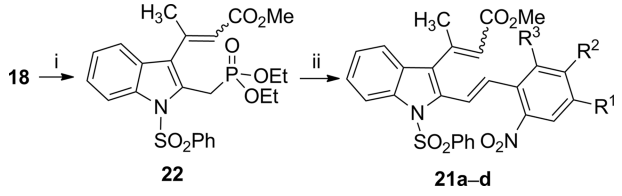
Scheme 2. Synthesis of bromo compound **18**. Reagents and conditions: (i) Methyl acetoacetate (**15**), $FeCl_3$ (20 mol-%), 1,2-DCE, room temp., 3 h, 93%; (ii) $PhSO_2Cl$, 60% NaOH/toluene, Bu_4NHSO_4 (cat.), r.t., 2 h, 92%; (iii) NBS, CCl_4, AIBN (cat.), reflux, 2 h, 92%.

to formation of required 2′-nitrophenylvinylindole **21a** only in poor yield (Scheme 3). Most of starting aldehyde **19** was recovered unchanged possibly as a result of the low reactivity of the aldehyde carbonyl.



Scheme 3. Wittig–Horner reaction of indole-2-carboxaldehyde **19**. Reagents and conditions: (i) $(Bu_4N)_2Cr_2O_7$, $CHCl_3$, reflux, 2 h, 90%; (ii) NaH, THF, 0 °C, *o*-nitrobenzyl phosphonate ester **20**, 2 h.

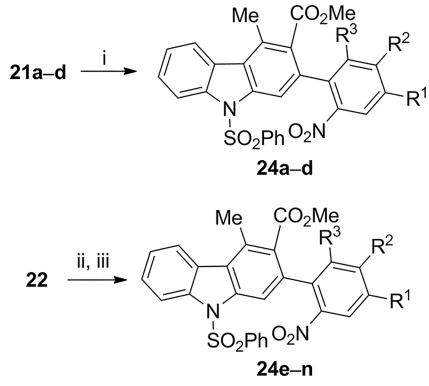
Next, the Michaelis–Arbuzov reaction of bromo compound **18** with triethyl phosphite at reflux temperatures followed by usual workup afforded 3-vinyl-2-indolylmethylphosphonate ester **22** in 91% yield. As expected, Wittig–Horner reaction of indolylmethyl phosphonate ester **22** with 2-nitroarylaldehydes **23a**–**23d** with NaH as a base in dry THF at 0 °C followed by workup and trituration of the crude products with methanol furnished 2,3-divinylindoles **21a**–**21d** as yellow solids in 75–82% yields (Scheme 4).



Scheme 4. Synthesis of 2′-nitrophenylvinylindoles **21a**–**21d**. Reagents and conditions: (i) $P(OEt)_3$, 140 °C, 2 h, 91%; (ii) NaH, THF, –10 °C to 0 °C, 2-nitroarylaldehydes **23a**–**23d,** 2 h, 75–82%.

The Wittig–Horner reaction of indolylmethylphosphonate ester **22** with 2-nitroarylaldehydes **23a**–**23d** was facile. However, if this reaction is performed at room temperature, unwanted cleavage of the phenylsulfonyl unit is observed.

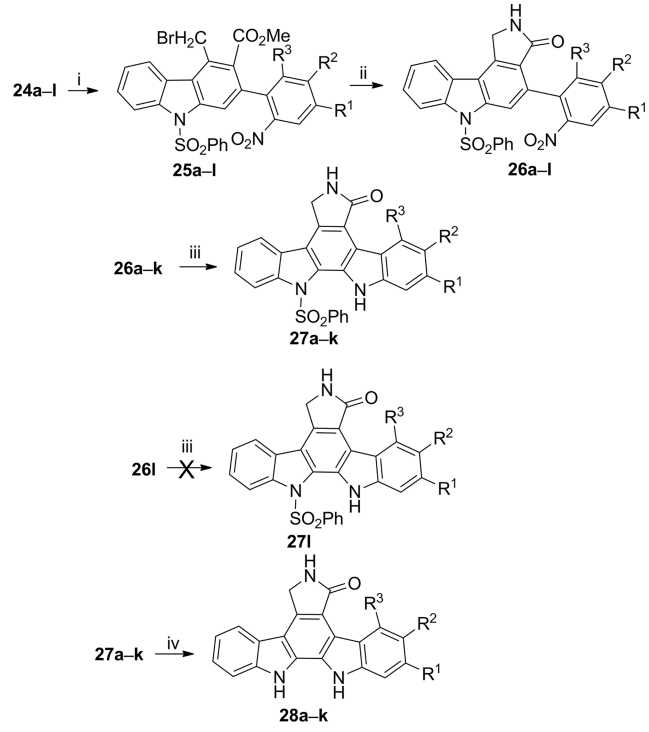
By heating a xylene solution of 2,3-divinylindoles **21a**–**21d** to reflux temperatures in the presence of 10% Pd/C smooth electrocyclization followed by aromatization to afford 2′-nitroarylcarbazoles **24a**–**24d** as yellow solids in excellent yields. The remaining 2′-nitroarylcarbazoles **24e**–**24n** were also prepared by Wittig–Horner reaction of phosphonate ester **22** with 2-nitroarylaldehydes **23e**–**23n** followed by thermal electrocyclization of the resulting vinylindoles (Scheme 5).



Scheme 5. Synthesis of 2′-nitroarylcarbazoles **24a**–**24n**. Reagents and conditions: (i) 10% Pd-C, xylenes, reflux, 24 h, 82–93%; (ii) NaH, THF, –10 °C–0 °C, **23e**–**23n** 2 h; (iii) 10% Pd-C, xylenes, reflux, 24 h, 81–90% (over two steps).

With 2′-nitroarylcarbazoles **24a**–**24n** in hand, further synthetic transformation into the indolocarbazole unit was planned. Initially, an allylic bromination of **24a** was performed with NBS (1.1 equiv.) in the presence of a catalytic amount of AIBN in CCl_4 at reflux temperatures. Under these conditions, the allylic bromination reaction was not completed and a significant amount of starting material **24a** was recovered (confirmed by ^1H NMR spectroscopy), which was possibly a result of the poor solubility of carbazole in CCl_4. Subsequently, the bromination reaction was performed in $CHCl_3$ at reflux temperatures, which also led to isolation of the starting material. However, by refluxing a dilute solution of 4-methylcarbazoles **24a**–**24l** in CCl_4 (100 mL per mmol of substrate) with NBS (2–3 equiv. in two portions) in the presence of AIBN furnished expected bromomethylcarbazoles **25a**–**25l** as yellow solids in good yields (Scheme 6). It should be noted that in the case of 4-methyl carbazole **24n**, the expected allylic bromination reaction was problematic and the ^1H NMR spectra of the crude product indicated the disappearance of the methylenedioxy unit.

Next, interaction of bromomethylcarbazoles **25a**–**25l** with aq. NH_3 in THF at reflux temperatures resulted in amides **26a**–26**l** as colorless solids. The further reaction of 2′-nitroarylcarbazoles **26a**–**26k** with triethyl phosphite in 1,2-dichlorobenzene (*o*-DCB) at reflux temperatures for 12 h effected final ring closure to afford indolocarbazoles



23–28	R^1	R^2	R^3	23–28	R^1	R^2	R^3
a	H	H	H	**h**	Cl	Cl	H
b	OMe	OMe	H	**i**	F	Cl	H
c	Cl	H	H	**j**	Cl	F	H
d	F	H	H	**k**	F	Br	H
e	H	F	H	**l**	H	Cl	Cl
f	H	Cl	H	**m**	H	H	Cl
g	H	Br	H	**n**		$-OCH_2O-$	H

Scheme 6. Synthesis of staurosporine aglycon **28a**–**28k**. Reagents and conditions: (i) NBS, CCl_4, AIBN (cat.), reflux, 4 h, 80–92%; (ii) aq. NH_3, THF, reflux, 2 h, 83–92%; (iii) $P(OEt)_3$, *o*-DCB, reflux, 12 h, 85–92%; (iv) K_2CO_3, MeOH/THF, reflux, 10 h, 83–91%.

27a–**27k** in excellent yields (Scheme 6). Expected nitrene insertion of 2′-nitroarylcarbazoles **26l** that are substituted at position 6 failed to produce expected indolocarbazole **27l** possibly as a result of atropisomerism, which may hinder the proximal position of the nitro group required for the insertion reaction. It is noteworthy to mention that the triethyl phosphite-mediated nitrene insertion of 2′-nitroarylcarbazoles **26a**–**26k** proceeded in excellent yields relative to the work by Moody in which a similar reaction afforded only a low yield for indolocarbazole.[21g] In addition, no *N*-ethylation products were observed as reported by Moody and co-workers. Excellent yields of indolocarbazoles obtained herein might be a result of the nitrene insertion reaction that takes place at the electron rich *meta*-position to the amide carbonyl unlike in the work by Moody in which the reaction occurred at the electron deficient *para*-position.

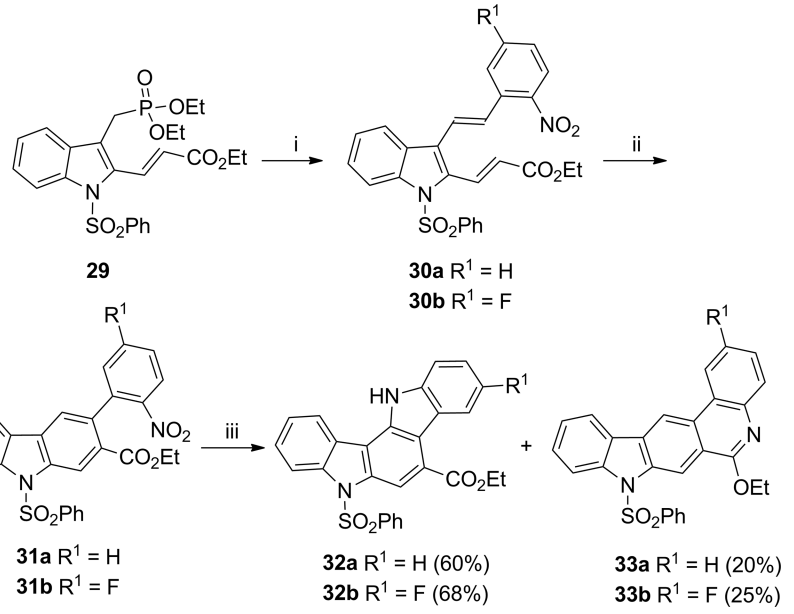
Initially, cleavage of the phenylsulfonyl unit of indolocarbazole **27a** was carried out with NaOH (50%) in dimethyl sulfoxide (DMSO) for 12 h. However, the usual work-up led to the formation of the lactam ring-opened product, which was identified by its ^1H NMR spectrum. Finally, expected cleavage of the phenylsulfonyl unit of indolocarbazoles **27a**–**27k** proceeded smoothly without affecting the amide unit with K_2CO_3 in MeOH/THF at reflux temperatures to afford staurosporine aglycons **28a**–**28k** as brown solids in good yields (Scheme 6).

After having completed the synthesis of indolo[2,3-*a*]carbazoles **28a**–**28k**, the synthesis of an isomeric indolo[3,2-*a*]carbazole analogue was planned by means of a similar protocol. Recently, an indolo[3,2-*a*]carbazole alkaloid, asteropusazole A **8** has been identified as a potential candidate for targeting neurological and psychiatric disorders.[13] Known phosphonate ester **29**,[27] upon Wittig–Horner reaction with 2-nitrobenzaldehydes (**23a/23e**) with K_2CO_3 as a base in dry dimethylformamide (DMF) at room temperature for 14 h followed by workup and purification by column chromatography, afforded divinyl compounds **30a/30b** as yellow solids.

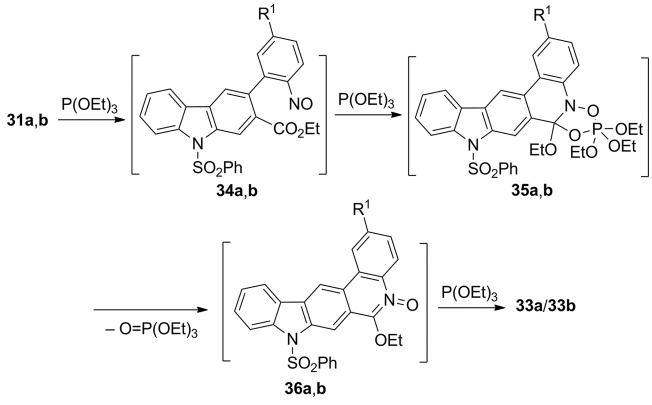
As expected, divinyl compounds **30a/30b** upon thermal electrocyclization in the presence of Pd/C (10%) in dry xylenes at reflux temperatures afforded carbazoles **31a/31b** in excellent yield. However, 3-(2′-nitrophenyl)carbazole compound **31a/31b** upon triethyl phosphite-mediated nitrene insertion at reflux temperatures for 6 h followed by workup and purification by column chromatography led to the isolation of indolocarbazole **32a/32b** and quinocarbazoles **33a/33b** in a 3:1 ratio (Scheme 7). The formation of quinocarbazoles **33a** and **33b** can be visualized through the intermediacy of corresponding 3-(2′-nitrosophenyl)carbazoles **34a** and **34b** (Scheme 8). The latter, upon triethyl phosphite-mediated condensation[31] followed by subsequent reduction of quinocarbazole *N*-oxides **36a** and **36b**, may lead to quinocarbazoles **33a** and **33b**.

The cyclin-dependent kinase (CDK) activity of the indolocarbazole analogues[3,12] prompted us to explore the activity of some representative staurosporinones. It should be noted that among CDKs, CDK5 represents an attractive pharmacological target as its deregulation is implicated in various neurodegenerative diseases such as Alzheimer's and Parkinson's. Hence, the CDK5 inhibition assay for representative indolocarbazoles **28a**–**28d** were performed with a LANCE® *Ultra* high-throughput screening technology platform optimized for homogeneous time-resolved fluorescence resonance energy transfer (TRFRET) kinase assays (see the Experimental Section for details). Staurosporine **1** and roscovitine **37** were used as standards for the CDK5/p25 assay of staurosporinones **28a**–**28d**.

The CDK5/p25 IC_{50} values (0.05–1.5 μM) of indolocarbazoles **28a**–**28d** are lower relative to parent alkaloid staurosporine **1** (IC_{50} 4 nM). However, the indolocarbazole CDK5/p25 IC_{50} values (0.05–1.5 μM) are similar to that of roscovitine ($IC_{50} \approx 0.5$–0.2 μM).[32] Among the four indolocarbazoles, chloro- and fluoro-indolocarbazole analogues **28c** (Figure 2) and **28d** (Figure 3), respectively, inhibit



Scheme 7. Synthesis of indolo[2,3-*c*]carbazoles **32a** and **32b,** and quinocarbazoles **33a** and **33b**. Reagents and conditions: (i) K_2CO_3, dry DMF, 2-nitroarylaldehydes (**23a**, **23e**), r.t, 14 h, 75%, 78% (ii) 10% Pd/C, xylenes, reflux, 24 h, 92%, 93%; (iii) $P(OEt)_3$, reflux, 6 h, 80–93%.



Scheme 8. Plausible mechanism for quinocarbazoles **33a** and **33b**.

CDK5/p25 enzyme at relatively low concentrations (0.05 μM & 0.12 μM). Similar to roscovitine,[33] staurosporinones may also inhibit kinase by competing with ATP at the ATP-binding site of the kinase.

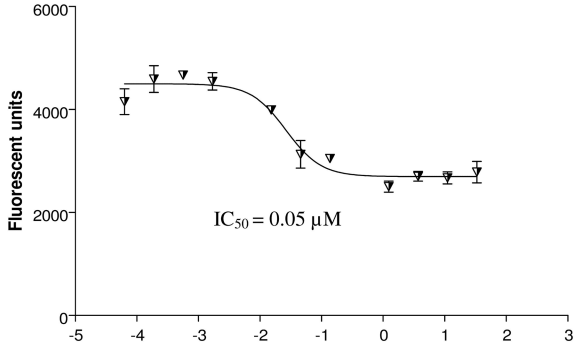


Figure 2. TRFRET CDK5/p25 assay of staurosporinone **28c**.

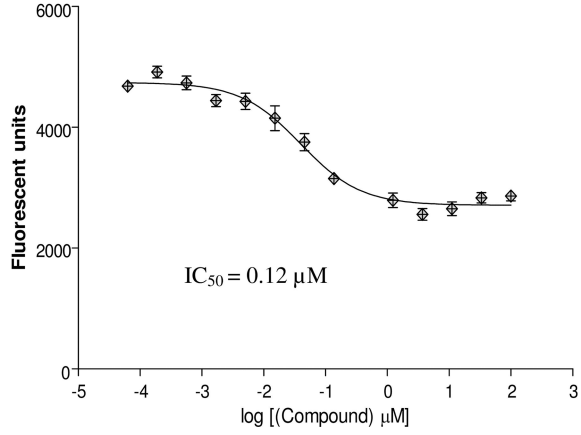


Figure 3. TRFRET CDK5/p25 assay of staurosporinone **28d**.

Conclusions

In summary, an efficient synthesis of staurosporinone and its analogues was achieved from commercially available 2-methylindole that involved multiple steps. Relative to existing syntheses of staurosporinone analogues, the present protocol is general and widely applicable.

By using this protocol, the synthesis of indolo[3,2-*a*]carbazole derivatives was also achieved. A mechanistic rationale for the formation of quinocarbazole during triethyl phosphite-mediated nitrene insertion of 3-(2′-nitrophenyl)carbazole has been reported. Among, the four staurosporinone analogues explored for CDK5/p25 inhibition studies, chloro and fluoro analogues inhibit the enzyme at relatively lower concentrations.

Experimental Section

General Methods: All the experiments were carried out under a nitrogen atmosphere unless otherwise stated. The progression of all reactions was monitored by TLC with ethyl acetate/hexanes mixtures. Column chromatography was carried out with Silica gel (230–400 mesh, Merck) by increasing polarity. ^{1}H NMR, ^{13}C NMR, and DEPT 135 spectra were recorded in $CDCl_3$ and [D_6]-DMSO with tetramethylsilane as an internal standard with a Bruker 300 MHz spectrometer at room temperature. Chemical shift values were quoted in parts per million (ppm) and coupling constants were quoted in Hertz (Hz). Elemental analysis data was recorded with a Elementar Vario Series Analyzer instrument. HRMS data was recorded with a JEOL GC Mate II (EI). Required 2-nitrobenzaldehydes **23a**–**23n** were prepared by using reported procedures.

Methyl (*E*)-3-(2-Methyl-1*H*-indol-3-yl)but-2-enoate (16): To a solution of 2-methylindole (**14**; 1 g, 7.63 mmol) and methyl acetoacetate (0.98 mL, 9.16 mmol) in dry 1,2-dichloroethane (DCE; 5 mL) under N_2 was added $FeCl_3$ (0.24 g, 1.52 mmol) and stirred for 3 h. After consumption of **14**, the solvent was removed under reduced pressure. Then, the residue was dissolved in ethyl acetate (30 mL) and water (10 mL). The organic layer was separated and washed with brine solution (2× 5 mL) and dried (Na_2SO_4). The solvent was removed under reduced pressure and the solid obtained was triturated with MeOH to afford vinyl indole **16** as a brown solid. 1.63 g (93%). M.p. 136–138 °C. IR (KBr): $\tilde{\nu}$ = 3251, 1651 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.11 (br. s, 1 H, NH), 7.64 (d, J = 8.1 Hz, 1 H, ArH), 7.30–7.26 (m, 1 H, ArH), 7.18–7.12 (m, 2 H, ArH), 5.95 (s, 1 H, vinylic CH), 3.76 (s, 3 H, CO_2Me), 2.67 (s, 3 H, Me), 2.50 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.8, 152.6, 135.1, 133.0, 127.0, 121.8, 120.4, 119.6, 116.7, 116.6, 110.5, 50.9, 20.5, 13.5 ppm.

Methyl (*E*)-3-[2-Methyl-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (17): To a solution of (*E*)-methyl 3-(2-methyl-1*H*-indol-3-yl)but-2-enoate **16** (1 g, 4.36 mmol) in toluene (10 mL), $PhSO_2Cl$ (0.61 mL, 4.80 mmol) and NaOH solution (50%, 10 mL) were added along with Bu_4NHSO_4 (100 mg, 0.29 mmol). The two-phase system was stirred at room temperature for 2 h, and then diluted with water (10 mL) and the organic layer was separated. The aqueous layer was extracted with toluene (10 mL) and the combined organic extract was dried (Na_2SO_4). The solvent was removed under reduced pressure and the solid obtained was washed with MeOH to afford compound **17** as brown crystals. 1.48 g (92%). M.p. 118–120 °C. IR (KBr): $\tilde{\nu}$ = 1685, 1609, 1365, 1174 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.22 (d, J = 8.1 Hz, 1 H, ArH), 8.79 (d, J = 7.5 Hz, 2 H, ArH), 7.57–7.53 (m, 1 H, ArH), 7.47–7.35 (m, 3 H, ArH), 7.33–7.21 (m, 2 H, ArH), 5.82 (s, 1 H, Vinylic CH), 3.75 (s, 3 H, CO_2Me), 2.57 (s, 3 H, Me), 2.48 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.7, 149.8, 139.2, 136.3, 133.8, 132.8, 129.4, 128.5, 126.3, 124.7, 124.5, 123.8, 121.1, 119.3, 114.6, 51.1, 20.3, 13.6 ppm. $C_{20}H_{19}NO_4S$ (369.43): C 65.02, H 5.18, N 3.79; found C 65.28, H 5.31, N 3.93.

Methyl 3-[2-Bromomethyl-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (18): A mixture of 1-(phenylsulfonyl)-2-methylindole (**17**; 1 g, 2.71 mmol) and NBS (0.53 g, 2.98 mmol) in dry CCl_4 (25 mL) that contained a catalytic amount of AIBN (20 mg, 0.12 mmol) was heated to reflux for 2 h. The reaction mixture was then cooled to room temperature. The insoluble succinimide was filtered off and the filtrate was concentrated under reduced pressure to afford bromo compound **18** as a thick brown liquid. 1.12 g (92%). The crude product was used in the next step without further purification. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.05–8.00 (m, ArH), 7.87–7.81 (m, ArH), 7.49–7.44 (m, ArH), 7.38–7.26 (m, ArH), 7.20–7.06 (m, ArH), 6.18 (s, 0.3 H, Vinylic CH), 6.02 (d, J = 1.2 Hz, 0.7 H, Vinylic CH), 4.95 (s, 1.4 H, CH_2Br), 4.80 (s, 0.7 H, CH_2Br), 3.74 (s, 1 H, OMe), 3.69 (s, 2 H, OMe), 2.45 (s, 2 H, Me), 2.25 (s, 1 H, Me) ppm. (^{1}H signals show a 2:1 *E*/*Z* isomeric mixture).

Methyl 3-[2-Formyl-1-(phenylsulfonyl)-1*H*-indol-3-yl]but-2-enoate (19): To the solution of bromo compound **18** (1 g, 2.23 mmol) in dry $CHCl_3$ (20 mL), tetrabutyl ammonium dichromate (2.34 g, 3.3 mmol) was added and heated to reflux for 2 h. After consumption of the bromo compound (monitored by TLC), the reaction mixture was concentrated under reduced pressure and the crude product was purified by flash column chromatography (EtOAc/hexanes, 1:99) to afford indole 2-aldehyde **19** as a colorless solid. 1.12 g (90%). M.p. 110–112 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 10.5 (s, 1 H, CHO), 8.26 (d, J = 8.7 Hz, 2 H, ArH), 7.82 (d, J = 8.1 Hz, 1 H, ArH), 7.60–7.29 (m, 8 H, ArH), 5.83 (d, J = 1.5 Hz, 1 H, vinylic CH), 3.75 (s, 3 H, CO_2Me), 2.45 (s, 3 H, Me) ppm.

Diethyl {3-[1-(Methoxycarbonyl)prop-1-en-2-yl]-1-(phenylsulfonyl)-indol-2-yl}methylphosphonate (22): A solution of crude bromo compound **18** (1 g, 2.23 mmol) and triethyl phosphite (0.63 g, 3.79 mmol) was heated to reflux under N_2 for 2 h. After consumption of bromo compound **18** (monitored by TLC), the reaction mixture was poured over crushed ice (100 g) that contained conc. HCl (2 mL), and extracted with $CHCl_3$ (50 mL). The organic layer was washed with brine (2× 25 mL) and dried (Na_2SO_4). The solvent was removed under reduced pressure to give phosphonate ester **22** as a brown thick liquid. 1.03 g (91%). The crude product was used in the next step without further purification. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.02–7.99 (m, 1 H, ArH), 7.99–7.70 (m, 4 H, ArH), 7.49–7.44 (m, 1 H, ArH), 7.38–7.33 (m, 2 H, ArH), 7.25–7.20 (m, 1 H, ArH), 6.51 (d, J = 16.2 Hz, 1 H, vinylic CH), 4.08 (q, J = 7.2 Hz, 4 H, OCH_2), 3.98 (d, J = 23.1 Hz, 2 H, CH_2-P), 3.75 (s, 3 H, -OCH_3), 3.25 (s, 3 H, CH_3), 1.22 (t, J = 7.1 Hz, 6 H, CH_3) ppm.

General Procedure for Wittig–Horner Reaction of the Phosphonate Ester with 2-Nitroarylaldehydes: To a solution of phosphonate ester **22** (1.93 mmol) in dry THF (5 mL), a suspension of hexane-washed NaH (0.07 g, 2.91 mmol, 5 mL of hexane) in dry THF (5 mL) at –10 °C under N_2 was slowly added and stirred for 15 min. Then, a solution of 2-nitroarylaldehyde **23a**–**23n** (2.32 mmol) in dry THF (2 mL) was added and allowed to stir for an additional 2 h. Once the reaction was complete (monitored by TLC), it was poured over crushed ice (100 g) that contained conc. HCl (3 mL). The solid formed was filtered and washed with MeOH to afford vinylindoles **21a**–**21d** and **21n**. Crude vinylindoles **21e–21m** were used in the next step (thermal electrocyclization reaction) without further characterization.

Methyl (2*E*)-3-[2-(2′-Nitrostyryl)-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (21a): Bright yellow solid. 0.77 g (80%). M.p. 138–140 °C. IR (KBr): $\tilde{\nu}$ = 1705, 1610, 1500, 1371, 1162 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.25 (d, J = 8.1 Hz, 1 H, ArH), 8.06 (d, J = 7.5 Hz, 1 H, ArH), 7.85–7.68 (m, 4 H, ArH), 7.63 (d, J = 15.9 Hz, 1 H, Vinylic CH), 7.53–7.36 (m, 6 H, ArH), 7.31–7.26 (m, 1 H, ArH), 7.21 (d, J = 16.2 Hz, 1 H, Vinylic CH), 5.99–5.98 (m, 1 H, Vinylic CH), 3.75 (s, 3 H, CO_2Me), 2.44 (d, J = 0.9 Hz, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.5, 149.2, 147.8, 37.6, 136.5, 134.1, 133.7, 132.5, 131.5, 129.4, 129.2, 129.0, 128.9, 127.2, 126.8, 126.0, 124.9, 124.5, 123.2, 122.0, 120.0, 115.4, 51.2, 20.0 ppm. HRMS (ESI): calcd. for $C_{27}H_{22}N_2NaO_6S$ [M + Na]$^+$ 525.1096; found 525.2391.

Methyl (2*E*)-3-[2-(4′,5′-Dimethoxy-2′-nitrostyryl)-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (21b): Bright yellow solid. 0.80 g (80%).

M.p. 150–151 °C. IR (KBr): ṽ = 1707, 1628, 1510, 1372, 1175 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.23 (d, J = 8.4 Hz, 1 H, ArH), 7.77 (d, J = 7.5 Hz, 2 H, ArH), 7.68 (s, 1 H, ArH), 7.57–7.50 (m, 2 H, ArH), 7.46–7.27 (m, 6 H, ArH), 7.18 (s, 1 H, ArH), 5.99 (s, 1 H, Vinylic CH), 4.09 (s, 3 H, OMe), 4.00 (s, 3 H, OMe), 3.75 (s, 3 H, OMe), 2.46 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.5, 153.5, 149.3, 149.0, 140.2, 137.5, 136.4, 134.0, 133.9, 132.6, 129.4, 129.2, 127.7, 126.9, 126.8, 125.9, 124.5, 122.0, 121.9, 119.9, 115.3, 109.9, 107.9, 56.5, 56.5, 51.2, 19.9 ppm. MS: m/z = 563 $[M]^+$.

Methyl (2*E*)-3-[2-(4′-Chloro-2′-nitrostyryl)-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (21c): Bright yellow solid. 0.85 g (82%). M.p. 140–142 °C. IR (KBr): ṽ = 1711, 1632, 1512, 1376, 1183 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.24 (d, J = 8.4 Hz, 1 H, ArH), 8.06 (d, J = 2.1 Hz, 1 H, ArH), 7.81–7.73 (m, 3 H, ArH), 7.69–7.61 (m, 2 H, ArH), 7.55–7.50 (m, 1 H, ArH), 7.45–7.37 (m, 4 H, ArH), 7.30 (d, J = 7.2 Hz, 1 H, ArH), 7.16 (d, J = 16.2 Hz, 1 H, Vinylic CH), 5.97 (s, 1 H, Vinylic CH), 3.75 (s, 3 H, OMe), 2.43 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.4, 149.0, 147.8, 137.5, 136.5, 134.7, 134.1, 133.7, 133.2, 130.9, 130.0, 129.9, 129.3, 129.2, 127.4, 126.7, 126.1, 125.0, 124.6, 123.7, 122.1, 120.0, 115.3, 51.2, 19.9 ppm. HRMS (EI): calcd. for $C_{27}H_{21}ClN_2O_6S$ $[M]^+$ 536.0809; found 536.0819.

Methyl (2*E*)-3-[2-(4′-Fluoro-2′-nitrostyryl)-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (21d): Bright yellow solid. 0.75 g (75%). M.p. 160–162 °C. IR (KBr): ṽ = 1712, 1635, 1500, 1371, 1176 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.24 (d, J = 8.4 Hz, 1 H, ArH), 7.56–7.75 (m, 4 H, ArH), 7.58 (d, J = 15.9 Hz, 1 H, ArH), 7.53–7.36 (m, 6 H, ArH), 7.31–7.26 (m, 1 H, ArH), 7.17 (d, J = 16.2 Hz, 1 H, Vinylic CH), 5.95 (s, 1 H, Vinylic CH), 3.75 (s, 3 H, OMe), 2.44 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.4, 149.1, 137.5, 136.4, 134.1, 133.3, 130.7, 130.4, 129.3, 129.2, 128.3, 127.2, 126.7, 126.0, 124.6, 123.3, 122.0, 121.4, 121.1, 120.0, 115.3, 112.7, 112.3, 51.2, 20.0 ppm.

Methyl (2*E*)-3-[2-(4′,5′-Methylenedioxy-2′-nitrostyryl)-1-(phenylsulfonyl)indol-3-yl]but-2-enoate (21n): Bright yellow solid. 0.78 g (80%). M.p. 144–146 °C. IR (KBr): ṽ = 1708, 1626, 1619, 1375, 1172 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.24 (d, J = 9 Hz, 1 H, ArH), 7.77 (d, J = 7.5 Hz, 2 H, ArH), 7.58–7.35 (m, 8 H, ArH), 7.30–7.25 (m, 2 H, ArH), 7.19 (s, 1 H, ArH), 6.18 (s, 2 H, ArH), 5.97 (s, 1 H, Vinylic CH), 3.75 (s, 3 H, OMe), 2.43 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.4, 152.2, 149.2, 148.0, 137.5, 136.4, 134.0, 133.7, 132.2, 129.6, 129.3, 129.2, 127.0, 126.8, 125.9, 124.5, 122.2, 121.9, 119.9, 115.3, 107.3, 105.63, 103.21, 51.19, 20.00 ppm. MS: m/z = 547 $[M + 1]^+$.

General Procedure for Electrocyclization Reaction of 1-(Phenylsulfonyl)-2,3-divinylindoles: To solution of divinyl compound **21a**–**21n** (1 g) in dry xylene (10 mL), 10% Pd/C (0.1 g) was added. The reaction mixture was heated to reflux for 24 h. Then, the reaction mixture was filtered through a Celite pad and washed with hot xylenes (3× 10 mL). The combined filtrate was concentrated under reduced pressure and the resulting crude product was triturated with MeOH (5 mL) to afford carbazoles **24a**–**24n** as pale yellow solids.

Methyl 4-Methyl-2-(2′-nitrophenyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (24a): 0.85 g (85%). M.p. 206–208 °C. IR (KBr): ṽ = 1709, 1598, 1372, 1174 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.04–8.00 (m, 2 H, ArH), 8.18 (s, 1 H, ArH), 7.72 (d, J = 7.8 Hz, 2 H, ArH), 7.62–7.57 (m, 1 H, ArH), 7.54–7.46 (m, 2 H, ArH), 7.43–7.26 (m, 5 H, ArH), 3.53 (s, 3 H, OMe), 2.76 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 169.0, 149.0, 139.1, 138.5, 137.1, 135.5, 135.3, 134.2, 132.5, 132.1, 131.6, 129.3, 129.2, 128.9, 127.5, 126.7, 126.5, 125.1, 124.5, 124.3, 123.0, 115.3, 113.7, 52.0, 18.3 ppm. $C_{27}H_{20}N_2O_6S$ (500.52): calcd. C 64.79, H 4.03, N 5.60; found C 65.01, H 4.18, N 5.99.

Methyl 2-(4′,5′-Dimethoxy-2′-nitrophenyl)-4-methyl-9-(phenylsulfonyl)carbazole-3-carboxylate (24b): 0.90 g (90%). M.p. 190–192 °C. IR (KBr): ṽ = 1731, 1592, 1517, 1372, 1175 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.43 (d, J = 8.4 Hz, 1 H, ArH), 8.24 (s, 1 H, ArH), 8.07 (d, J = 7.8 Hz, 1 H, ArH), 7.78–7.75 (m, 2 H, ArH), 7.72 (s, 1 H, ArH), 7.57–7.52 (m, 1 H, ArH), 7.49–7.44 (m, 2 H, ArH), 7.40–7.32 (m, 2 H, ArH), 6.81 (s, 1 H, ArH), 4.03 (s, 3 H, OMe), 3.95 (s, 3 H, OMe), 3.59 (s, 3 H, OMe), 2.75 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 169.2, 152.3, 148.4, 141.2, 139.1, 138.5, 137.1, 135.9, 134.1, 131.3, 129.8, 129.5, 129.2, 127.5, 126.7, 126.5, 124.9, 124.4, 123.0, 115.3, 113.7, 113.6, 107.6, 56.6, 56.5, 52.2, 18.2 ppm. $C_{29}H_{24}N_2O_8S$ (560.57): calcd. C 62.13, H 4.32, N 5.00; found C 62.33, H 4.61, N 5.27.

Methyl 2-(4′-Chloro-2′-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-carbazole-3-carboxylate (24c): 0.93 g (93%). M.p. 225–226 °C. IR (KBr): ṽ = 1719, 1580, 1379, 1174 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.1 Hz, 1 H, ArH), 8.14 (s, 1 H, ArH), 8.02–8.00 (m, 2 H, ArH), 7.70 (d, J = 7.8 Hz, 2 H, ArH), 7.56 (dd, J = 2.1, 8.1 Hz, 1 H, ArH), 7.49 (t, J = 8.1 Hz, 1 H, ArH), 7.43–7.35 (m, 2 H, ArH), 7.32–7.18 (m, 2 H, ArH), 7.07–7.01 (m, 1 H, ArH), 3.51 (s, 3 H, OMe), 2.69 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.6, 149.1, 139.3, 139.1, 137.0, 135.1, 134.9, 134.4, 133.6, 133.1, 132.7, 130.8, 129.4, 128.5, 126.6, 125.0, 124.6, 124.5, 124.1, 116.3, 115.3, 52.4, 27.6 ppm. $C_{27}H_{19}ClN_2O_6S$ (534.97): calcd. C 60.62, H 3.58, N 5.24; found C 60.83, H 3.75, N 5.38.

Methyl 2-(4′-Fluoro-2′-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-carbazole-3-carboxylate (24d): 0.83 g (82%). M.p. 221–222 °C. IR (KBr): ṽ = 1720, 1615, 1381, 1177 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.15 (s, 1 H, ArH), 8.01 (d, J = 8.1 Hz, 1 H, ArH), 7.76 (d, J = 8.1 Hz, 1 H, ArH), 7.70 (d, J = 7.8 Hz, 2 H, ArH), 7.51–7.26 (m, 7 H, ArH), 3.50 (s, 3 H, OMe), 2.69 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.8, 161.64 (d, J = 251.8 Hz), 149.3, 139.0, 138.4, 137.1, 134.2, 133.7, 133.6, 131.7, 131.5, 129.4, 129.2, 127.6, 126.6, 126.5, 125.2, 124.5, 123.0, 119.7 (d, J = 21.1 Hz) 115.3, 113.8, 112.0 (d, J = 26.39 Hz), 52.1, 18.2 ppm. $C_{27}H_{19}FN_2O_6S$ (518.51): calcd. C 62.54, H 3.69, N 5.40; found C 62.82, H 3.83, N 5.71.

Methyl 2-(5′-Fluoro-2′-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-carbazole-3-carboxylate (24e): 0.84 g (84%). M.p. 202–203 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.44 (d, J = 8.4 Hz, 1 H, ArH), 8.24 (s, 1 H, ArH), 8.19–8.14 (m, 1 H, ArH), 8.09 (d, J = 8.1 Hz, 1 H, ArH), 7.79–7.76 (m, 2 H, ArH), 7.59–7.50 (m, 1 H, ArH), 7.48–7.45 (m, 2 H, ArH), 7.42–7.33 (m, 2 H, ArH), 7.29–7.23 (m, 1 H, ArH), 7.13 (dd, J = 2.7, 8.3 Hz, 1 H, ArH), 3.59 (s, 3 H, OMe), 2.77 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.7, 165.6, 162.2, 145.1, 139.1, 138.8 (d, J = 9.6 Hz), 138.5, 137.1, 134.4, 134.2, 132.0, 129.3, 128.9, 127.7, 127.1 (d, J = 9.9 Hz), 126.5, 125.4, 124.5, 123.1, 119.2 (d, J = 24 Hz), 115.9 (d, J = 23 Hz), 52.1, 18.3 ppm. $C_{27}H_{19}FN_2O_6S$ (518.51): calcd. C 62.54, H 3.69, N 5.40; found C 62.81, H 3.91, N 5.72.

Methyl 2-(5-Chloro-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24f): 0.83 g (83%). M.p. 211–213 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.43 (d, J = 8.4 Hz, 1 H, ArH), 8.23 (s, 1 H, ArH), 8.09–8.04 (m, 2 H, ArH), 7.77 (d, J = 7.8 Hz, 2 H, ArH), 7.58–7.37 (m, 7 H, ArH), 3.59 (s, 3 H, OMe), 2.76 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.6, 147.2, 139.1, 138.8, 138.4, 137.3, 137.1, 134.2, 134.1, 132.0, 132.0, 129.2, 129.0, 128.9, 127.7, 126.5, 125.7, 125.4, 124.5, 123.1, 115.3, 113.4, 52.1, 18.2 ppm.

Methyl 2-(5-Bromo-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24g): 0.85 g (85%). M.p. 216–218 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.44 (d, J = 8.4 Hz, 1 H, ArH), 8.23 (s, 1 H, ArH), 8.09 (d, J = 7.8 Hz, 1 H, ArH), 7.97 (d, J = 8.7 Hz, 1 H, ArH), 7.78–7.69 (m, 3 H, ArH), 7.59–7.36 (m, 6 H, ArH), 3.60 (s, 3 H, OMe), 2.77 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.6, 147.7, 139.1, 138.4, 137.3, 137.1, 134.9, 134.2, 134.0, 132.0, 129.2, 128.9, 127.7, 127.1, 126.5, 125.6, 125.4, 124.5, 123.1, 115.3, 113.5, 52.1, 18.2 ppm. $C_{27}H_{19}BrN_2O_6S$ (579.42): calcd. C 55.97, H 3.31, N 4.83; found C 55.69, H 3.12, N 4.55.

Methyl 2-(4,5-Dichloro-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24h): 0.84 g (84%). M.p. 242–244 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.35 (d, J = 8.4 Hz, 1 H, ArH), 8.14 (S, 2 H, ArH), 8.01 (d, J = 7.8 Hz, 1 H, ArH), 7.68 (d, J = 7.5 Hz, 2 H, ArH), 7.51–7.29 (m, 7 H, ArH), 3.56 (s, 3 H, OMe), 2.69 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.4, 147.1, 139.0, 138.4, 137.3, 137.0, 135.2, 134.2, 133.4, 133.1, 132.1, 129.2, 128.7, 127.7, 126.4, 126.3, 126.1, 125.5, 124.5, 123.1, 115.2, 113.4, 52.2, 18.3 ppm.

Methyl 2-(5-Chloro-4-fluoro-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24i): 0.81 g (81%). M.p. 218–220 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.35 (d, J = 8.4 Hz, 1 H, ArH), 8.14 (s, 1 H, ArH), 8.01 (d, J = 8.1 Hz, 1 H, ArH), 7.86 (d, J = 8.4 Hz, 1 H, ArH), 7.68 (d, J = 7.8 Hz, 2 H, ArH), 7.54–7.18 (m, 6 H, ArH), 3.55 (s, 3 H, OMe), 2.68 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.5, 158.7, 155.3, 147.3, 147.2, 139.0, 138.4, 137.0, 134.2, 133.8, 133.2, 132.6, 132.0, 129.2, 128.9, 127.7, 126.4, 126.3, 126.1, 125.4, 124.5, 123.1, 115.2, 113.6, 113.2, 112.9, 52.2, 18.3 ppm.

Methyl 2-(4-Chloro-5-fluoro-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24j): 0.81 g (81%). M.p. 244–246 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.44 (d, J = 8.4 Hz, 1 H, ArH), 8.24–8.21 (m, 2 H, ArH), 8.07 (d, J = 8.1 Hz, 1 H, ArH), 7.75 (d, J = 7.5 Hz, 2 H, ArH), 7.58–7.21 (m, 6 H, ArH), 3.63 (s, 3 H, OMe), 2.76 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.5, 161.3, 157.8, 144.9, 139.0, 138.4, 137.1, 136.8, 136.7, 134.2, 133.4, 132.2, 129.2, 128.7, 127.8, 127.3, 126.4, 126.4, 125.5, 124.5, 123.1, 121.9, 121.6, 120.1, 119.8, 115.2, 113.3, 52.2, 18.3 ppm.

Methyl 2-(5-Bromo-4-fluoro-2-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24k): 0.89 g (89%). M.p. 228–230 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.44 (d, J = 8.8 Hz, 1 H, ArH), 8.22 (s, 1 H, ArH), 8.09 (d, J = 8.1 Hz, 1 H, ArH), 7.89 (d, J = 7.8 Hz, 1 H, ArH), 7.76 (d, J = 8.1 Hz, 2 H, ArH), 7.67 (d, J = 6.9 Hz, 1 H, ArH), 7.59–7.38 (m, 5 H, ArH), 3.62 (s, 3 H, OMe), 2.76 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.7, 159.9, 156.6, 148.1, 139.1, 138.5, 137.1, 136.7, 134.2, 133.2, 132.7, 132.7, 132.7, 132.0, 129.2, 129.0, 127.7, 126.5, 126.4, 125.5, 124.5, 123.1, 115.3, 114.7, 114.4, 113.7, 112.9, 112.5, 52.2, 18.3 ppm.

Methyl 2-(2,3-Dichloro-6-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24l): 0.90 g (90%). M.p. 226–228 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.47 (d, J = 8.4 Hz, 1 H, ArH), 8.13 (s, 1 H, ArH), 8.02 (d, J = 7.8 Hz, 1 H, ArH), 7.88 (d, J = 8.7 Hz, 1 H, ArH), 7.69 (d, J = 7.8 Hz, 2 H, ArH), 7.62 (d, J = 8.7 Hz, 1 H, ArH), 7.49 (t, J = 7.6 Hz, 1 H, ArH), 7.41–7.18 (m, 4 H, ArH), 3.53 (s, 3 H, OMe), 2.73 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.1, 148.3, 139.1, 138.8, 138.4, 137.0, 136.5, 135.1, 134.2, 132.5, 130.1, 129.1, 128.4, 127.8, 126.6, 126.5, 126.0, 124.5, 123.2, 122.9, 115.3, 114.0, 52.0, 18.6 ppm. $C_{27}H_{18}Cl_2N_2O_6S$ (569.41): calcd. C 56.95, H 3.19, N 4.92; found C 57.24, H 3.48, N 4.65.

Methyl 2-(2-Chloro-6-nitrophenyl)-4-methyl-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (24m): 0.81 g (81%). M.p. 226–228 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.17 (s, 1 H, ArH), 8.01 (d, J = 8.1 Hz, 1 H, ArH), 7.91 (d, J = 8.1 Hz, 1 H, ArH), 7.72–7.68 (m, 3 H, ArH), 7.48–7.34 (m, 4 H, ArH), 7.27–7.18 (m, 2 H, ArH), 3.49 (s, 3 H, OMe), 2.71 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.2, 150.3, 139.1, 138.7, 137.0, 136.4, 134.3, 134.1, 133.7, 132.5, 132.4, 129.3, 129.1, 128.8, 127.6, 126.7, 126.5, 125.8, 124.5, 123.5, 123.1, 122.4, 115.3, 114.3, 51.9, 18.4 ppm.

Methyl 4-Methyl-2-(5-nitrobenzo[*d*][1,3]dioxol-6-yl)-9-(phenylsulfonyl)carbazole-3-carboxylate (24n): 0.89 g (89%). M.p. 203–204 °C. IR (KBr): $\tilde{\nu}$ = 1721, 1482, 1374, 1174 cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.43 (d, J = 8.4 Hz, 1 H, ArH), 8.22 (s, 1 H, ArH), 8.06 (d, J = 7.8 Hz, 1 H, ArH), 7.76 (d, J = 7.5 Hz, 2 H, ArH), 7.60 (s, 1 H, ArH), 7.54 (t, J = 8.1 Hz, 1 H, ArH), 7.48–7.26 (m, 4 H, ArH), 6.79 (s, 1 H, ArH), 6.18 (s, 2 H, ArH), 3.63 (s, 3 H, OMe), 2.73 (s, 3 H, Me) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 169.1, 151.0, 147.2, 142.9, 139.0, 138.5, 137.1, 135.7, 134.2, 131.8, 131.4, 129.3, 129.2, 127.5, 126.7, 126.5, 125.0, 124.5, 123.0, 115.3, 113.6, 111.1, 105.3, 103.2, 52.2, 18.3 ppm. $C_{28}H_{20}N_2O_8S$ (544.53): calcd. C 61.76, H 3.70, N 5.14; found C 62.00, H 3.91, N 5.44.

General Procedure for Allylic Bromination of 2-(2′-Nitroaryl)-4-methylcarbazoles: A mixture of 4-methylcarbazole **24a**–**24l** (1 mmol) and NBS (1.5 mmol) in dry CCl_4 (100 mL) that contained a catalytic amount of AIBN (0.1 mmol) was heated to reflux for 2 h. Then, the reaction mixture was cooled to room temperature and an additional portion of NBS (1.5 mmol) and AIBN (0.1 mmol) was added and heated to reflux for a further 2 h. Then, the reaction mixture was cooled to room temperature and the insoluble succinimide was filtered off through a Na_2SO_4 pad under hot conditions. Removal of solvent under reduced pressure followed by trituration of the crude product from methanol (10 mL) furnished 4-bromomethyl carbazoles **25a**–**25l** as pale yellow solids.

Methyl 4-(Bromomethyl)-2-(2′-nitrophenyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (25a): 0.51 g (89%). M.p. 194–196 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.46 (d, J = 8.4 Hz, 1 H, ArH), 8.40 (s, 1 H, ArH), 8.21 (d, J = 7.8 Hz, 1 H, ArH), 8.13 (dd, J = 1.4, 8.0 Hz, 1 H, ArH), 7.82–7.79 (m, 2 H, ArH), 7.71–7.58 (m, 3 H, ArH), 7.57–7.36 (m, 5 H, ArH), 5.06 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.89 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.56 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.8, 148.9, 139.3, 139.1, 137.0, 136.3, 135.1, 134.4, 132.6, 132.0, 130.6, 129.4, 129.2, 128.6, 128.3, 126.6, 125.0, 124.8, 124.6, 124.4, 124.0, 116.4, 115.3, 52.3, 27.7 ppm. HRMS (ESI): calcd. for $C_{27}H_{19}BrKN_2O_6S$ [M + K]$^+$ 616.9784; found 616.5785.

Methyl 2-(4′,5′-Dimethoxy-2′-nitrophenyl)-4-(bromomethyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (25b): 0.59 g (92%). M.p. 216–218 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.45 (d, J = 8.4 Hz, 1 H, ArH), 8.38 (s, 1 H, ArH), 8.20 (d, J = 7.8 Hz, 1 H, ArH), 7.79 (d, J = 7.8 Hz, 2 H, ArH), 7.74 (s, 1 H, ArH), 7.62 (t, J = 8.0 Hz, 1 H, ArH), 7.50 (t, J = 7.7 Hz, 2 H, ArH), 7.37 (t, J = 7.7 Hz, 2 H, ArH), 6.82 (s, 1 H, ArH), 5.04 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.86 (d, J = 11.0 Hz, 1 H, CH_2Br), 4.05 (s, 3 H, OMe), 3.96 (s, 3 H, OMe), 3.62 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.0, 152.4, 148.6, 141.1, 139.3, 139.1, 137.0, 136.5, 134.4, 130.2, 129.3, 128.9, 128.3, 126.6, 125.0, 124.7, 124.6, 124.0, 116.5, 115.3, 113.4, 107.6, 56.7, 56.5, 52.5, 27.8 ppm.

Methyl 4-(Bromomethyl)-2-(4′-chloro-2′-nitrophenyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (25c): 0.55 g (91%). M.p. 192–193 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.46 (d, J = 8.4 Hz, 1 H, ArH), 8.35 (s, 1 H, ArH), 8.21 (d, J = 7.8 Hz, 1 H, ArH), 8.13 (d, J =

1.8 Hz, 1 H, ArH), 7.79 (d, J = 7.5 Hz, 2 H, ArH), 7.67–7.60 (m, 2 H, ArH), 7.50 (t, J = 7.4 Hz, 2 H, ArH), 7.41–7.26 (m, 3 H, ArH), 5.05 (d, J = 11 Hz, 1 H, CH_2Br), 4.88 (d, J = 11 Hz, 1 H, CH_2Br), 3.62 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.6, 149.1, 139.3, 139.1, 137.0, 135.1, 134.9, 134.4, 133.6, 133.1, 132.7, 130.8, 129.4, 128.5, 126.5, 125.0, 124.6, 124.5, 124.1, 116.3, 115.3, 52.4, 27.6 ppm.

Methyl 2-(4′-Fluoro-2′-nitrophenyl)-4-(bromomethyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (25d): 0.52 g (88%). M.p. 163–165 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.46 (d, J = 8.4 Hz, 1 H, ArH), 8.37 (s, 1 H, ArH), 8.21 (d, J = 8.1 Hz, 1 H, ArH), 7.87 (dd, J = 2.1, 8.4 Hz, 1 H, ArH), 7.81–7.78 (m, 2 H, ArH), 7.65–7.60 (m, 1 H, ArH), 7.53–7.48 (m, 2 H, ArH), 7.44–7.36 (m, 4 H, ArH), 5.05 (d, J = 11.0 Hz, 1 H, CH_2Br), 4.88 (d, J = 11.0 Hz, 1 H, CH_2Br), 3.61 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.7, 139.3, 139.1, 137.0, 135.0, 134.4, 133.6 (d, J = 31.2 Hz), 131.2 (d, J = 4.9 Hz), 130.7, 129.4, 128.8, 128.5, 126.6, 125.0, 125.0, 124.5, 124.1, 119.9 (d, J = 20.96 Hz), 116.5, 115.3, 112.2 (d, J = 26.5 Hz), 52.4, 27.6 ppm.

Methyl 2-(5′-Fluoro-2′-nitrophenyl)-4-(bromomethyl)-9-(phenylsulfonyl)carbazole-3-carboxylate (25e): 0.55 g (93%). M.p. 180–182 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.46 (d, J = 8.4 Hz, 1 H, ArH), 8.38 (s, 1 H, ArH), 8.23–8.19 (m, 2 H, ArH), 7.80–7.78 (m, 2 H, ArH), 7.67–7.60 (m, 1 H, ArH), 7.54–7.49 (m, 2 H, ArH), 7.42–7.36 (m, 2 H, ArH), 7.32–7.28 (m, 1 H, ArH), 7.15 (dd, J = 2.7, 8.1 Hz, 1 H, ArH), 5.06 (d, J = 11.1 Hz, 1 H, CH_2Br), 4.91 (d, J = 11.1 Hz, 1 H, CH_2Br), 3.63 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.5, 139.4, 139.1, 138.4 (d, J = 13.3 Hz), 137.1, 135.1, 134.4, 130.9, 129.4, 128.5, 128.2, 127.2 (d, J = 12.1 Hz), 126.6, 125.1, 125.0, 124.5, 124.1, 119.4, 119.0, 116.3, 116.0, 115.9, 115.3, 52.4, 27.5 ppm.

Methyl 4-(Bromomethyl)-2-(5-chloro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25f): 0.54 g (89%). M.p. 198–200 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.1 Hz, 1 H, ArH), 8.29 (s, 1 H, ArH), 8.13 (d, J = 7.8 Hz, 1 H, ArH), 8.01 (d, J = 8.7 Hz, 1 H, ArH), 7.71 (d, J = 7.8 Hz, 2 H, ArH), 7.56–7.32 (m, 7 H, ArH), 4.98 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.82 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.55 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.4, 147.0, 139.3, 139.1, 139.0, 136.9, 139.0, 136.9 (d, J = 5.9 Hz), 134.9, 134.4, 131.9, 130.9, 129.3, 129.2, 128.5, 128.2, 126.5, 125.8, 125.1, 125.0, 124.4, 124.1, 116.1, 115.3, 52.4, 27.5 ppm.

Methyl 2-(5-Bromo-2-nitrophenyl)-4-(bromomethyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25g): 0.53 g (80%). M.p. 198–200 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.45 (d, J = 8.4 Hz, 1 H, ArH), 8.37 (s, 1 H, ArH), 8.21 (d, J = 7.8 Hz, 1 H, ArH), 8.01 (d, J = 8.4 Hz, 1 H, ArH), 7.80–7.35 (m, 9 H, ArH), 5.05 (d, J = 11.1 Hz, 1 H, CH_2Br), 4.90 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.63 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.4, 147.5, 139.3, 139.0, 137.0, 136.9, 134.8, 134.4, 132.3, 130.9, 129.4, 128.5, 128.2, 127.4, 126.5, 125.8, 125.1, 125.0, 124.4, 124.1, 116.2, 115.3, 52.4, 27.6 ppm.

Methyl 4-(Bromomethyl)-2-(4,5-dichloro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25h): 0.56 g (86%). M.p. 195–197 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.45 (d, J = 8.4 Hz, 1 H, ArH), 8.34 (s, 1 H, ArH), 8.25–8.20 (m, 2 H, ArH), 7.77 (d, J = 7.8 Hz, 2 H, ArH), 7.66–7.38 (m, 6 H, ArH), 5.05 (d, J = 11.1 Hz, 1 H, CH_2Br), 4.92 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.68 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.0, 145.9, 138.0, 137.7, 136.2, 135.7, 133.6, 133.5, 132.9, 132.7, 132.1, 129.9, 128.4, 127.6, 127.3, 127.2, 125.3, 125.2, 124.0, 123.8, 123.1, 123.0, 114.8, 114.1, 113.9, 51.4, 26.6 ppm.

Methyl 4-(Bromomethyl)-2-(5-chloro-4-fluoro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25i): 0.55 g (87%). M.p. 198–200 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.7 Hz, 1 H, ArH), 8.28 (s, 1 H, ArH), 8.13 (d, J = 7.8 Hz, 1 H, ArH), 7.90 (d, J = 8.1 Hz, 1 H, ArH), 7.70 (d, J = 7.5 Hz, 2 H, ArH), 7.57–7.27 (m, 6 H, ArH), 4.97 (d, J = 10.5 Hz, 1 H, CH_2Br), 4.81 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.59 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.3, 158.8, 155.4, 147.2, 147.1, 139.3, 139.0, 136.9, 134.0, 133.6, 132.2, 132.1, 130.9, 129.3, 128.5, 128.2, 126.5, 126.5, 126.3, 125.1, 125.0, 124.3, 124.0, 116.3, 115.2, 113.3, 113.0, 52.5, 27.5 ppm.

Methyl 4-(Bromomethyl)-2-(4-chloro-5-fluoro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25j): 0.56 g (89%). M.p. 197–199 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.45 (d, J = 8.4 Hz, 1 H, ArH), 8.34 (s, 1 H, ArH), 8.27 (d, J = 6.3 Hz, 1 H, ArH), 8.22 (d, J = 8.1 Hz, 1 H, ArH), 7.77 (d, J = 7.8 Hz, 2 H, ArH), 7.63 (t, J = 7.9 Hz, 1 H, ArH), 7.51 (t, J = 7.3 Hz, 2 H, ArH), 7.38 (t, J = 7.6 Hz, 2 H, ArH), 7.26–7.23 (m, 1 H, ArH), 5.05 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.90 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.68 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 161.4, 157.9, 144.7, 139.3, 139.0, 137.0, 136.3, 136.2, 134.2, 134.4, 134.1, 131.0, 129.3, 128.6, 127.9127.4, 126.5, 125.2, 125.0, 124.3124.1, 122.0 (d, J = 19.1 Hz), 119.8 (d, J = 23.2 Hz), 113.9, 115.2, 52.5, 27.4 ppm.

Methyl2-(5-bromo-4-fluoro-2-nitrophenyl)-4-(bromomethyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25k): 0.56 g (84%). M.p. 198–200 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.44 (d, J = 8.4 Hz, 1 H, ArH), 8.36 (s, 1 H, ArH), 8.20 (d, J = 7.8 Hz, 1 H, ArH), 7.93–7.90 (m, 1 H, ArH), 7.78–7.47 (m, 6 H, ArH), 7.36 (t, J = 7.3 Hz, 2 H, ArH), 5.04 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.88 (d, J = 10.5 Hz, 1 H, CH_2Br), 3.66 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 168.5, 160.0, 156.7, 148.0, 147.9, 139.2 (d, J = 19.6 Hz), 137.0, 136.6, 134.4, 133.9, 132.3, 132.3, 131.0, 129.3, 128.5, 128.3, 126.5, 125.2, 125.0, 124.3, 124.1, 116.4, 115.3, 114.7 (d, J = 21.2 Hz), 112.8 (d, J = 27.2 Hz), 52.5, 27.5 ppm.

Methyl 4-(Bromomethyl)-2-(2,3-dichloro-6-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-3-carboxylate (25l): 0.56 g (87%). M.p. 195–197 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.37 (d, J = 8.1 Hz, 1 H, ArH), 8.28 (s, 1 H, ArH), 8.13 (d, J = 7.8 Hz, 1 H, ArH), 7.90 (d, J = 8.4 Hz, 1 H, ArH), 7.70 (d, J = 7.5 Hz, 2 H, ArH), 7.55 (t, J = 7.65 Hz, 1 H, ArH), 7.26–7.23 (m, 5 H, ArH), 4.96 (d, J = 10.8 Hz, 1 H, CH_2Br), 4.80 (d, J = 10.8 Hz, 1 H, CH_2Br), 3.59 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.4, 158.8, 155.4, 147.2, 147.1, 139.1 (d, J = 17.3 Hz), 136.9, 134.4, 134.0, 133.6, 132.1 (d, J = 4.6 Hz), 130.9, 129.3, 128.5, 128.2, 126.5, 125.1, 125.0, 124.3, 124.0, 116.3, 115.2, 113.2 (d, J = 26.0 Hz), 52.5, 27.5 ppm.

General Procedure for Amidation Reaction of 4-(Bromomethyl)carbazoles (25a–25l): Aqueous NH_3 (10 mL, 25%) was added to a solution of bromo compound **25a**–**25l** (1 mmol) in THF (20 mL) and heated to reflux for 2 h. After consumption of the bromo compound (monitored by TLC), the solvent was concentrated under reduced pressure and the resulting residue was poured onto iced water (100 g). The solid obtained was filtered and dried (Na_2SO_4). The crude product was washed with $CHCl_3$ (1 mL) to afford amides **26a**–**26l** as brown solids.

4-(2-Nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26a): 0.44 g (92%). M.p. 304–308 °C. IR (KBr): $\tilde{\nu}$ = 3300, 1651, 1540, 1364, 1172 cm^{-1}. ^1H NMR (300 MHz, [D_6]-DMSO): δ = 8.68 (s, 1 H, NH), 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.23 (s, 1 H, ArH), 8.19 (dd, J = 1.2, 8.1 Hz, 1 H, ArH), 7.98 (d, J = 7.5 Hz, 1 H, ArH), 7.91–7.85 (m, 3 H, ArH), 7.76–7.49 (m, 4

H, ArH), 4.88 (d, J = 18.6 Hz, 1 H, CH_2), 4.77 (d, J = 18.6 Hz, 1 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.8, 148.6, 139.1, 138.8, 138.1, 136.3, 134.7, 133.3, 133.0, 132.7, 129.7, 129.1, 128.2, 126.2, 125.0, 124.9, 124.1, 123.8, 122.5, 120.5, 114.7, 114.5, 43.9 ppm. HRMS (FAB$^+$): calcd. for $C_{26}H_{17}N_3O_5S$ [M]$^+$ 483.0889, found 483.0892.

4-(4,5-Dimethoxy-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26b): 0.49 g (90%). M.p. 312–314 °C. IR (KBr): $\tilde{\nu}$ = 3290, 1645, 1537, 1371, 1175 cm^{-1}. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.67 (s, 1 H, NH), 8.39 (d, J = 8.4 Hz, 1 H, ArH), 8.19 (s, 1 H, ArH), 8.0 (d, J = 7.8 Hz, 1 H, ArH), 7.93 (d, J = 7.8 Hz, 2 H, ArH), 7.78 (s, 1 H, ArH), 7.72–7.65 (m, 2 H, ArH), 7.58–7.49 (m, 3 H, ArH), 6.99 (s, 1 H, ArH), 4.89 (d, J = 18.6 Hz, 1 H, CH_2), 4.76 (d, J = 18.6 Hz, 1 H, CH_2), 3.96 (s, 3 H, OMe), 3.94 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]-DMSO): δ = 168.9, 152.3, 148.0, 140.9, 139.0, 138.9, 138.139, 136.2, 135.4, 135.1, 129.8, 128.3, 127.4, 126.3, 125.3, 125.0, 124.1, 122.6, 120.1, 114.7, 114.5, 114.4, 107.4, 56.3, 56.1, 43.8 ppm.

4-(4-Chloro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo-[3,4-*c*]carbazol-3(6*H*)-one (26c): 0.47 g (91%). M.p. 314–320 °C. IR (KBr): $\tilde{\nu}$ = 3345, 1655, 1560, 1378, 1180 cm^{-1}. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.76 (s, 1 H, NH), 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.28–8.24 (m, 2 H, ArH), 8.02–7.91 (m, 4 H, ArH), 7.73–7.65 (m, 3 H, ArH), 7.58–7.50 (m, 3 H, ArH), 4.90 (d, J = 19 Hz, 1 H, CH_2), 4.79 (d, J = 19 Hz, 1 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.8, 149.1, 139.1, 139.0, 138.1, 136.2, 135.2, 134.3, 133.4, 133.4, 133.2, 131.65, 129.9, 128.6, 126.3, 125.1, 124.0, 123.8, 122.7, 120.7, 114.7, 114.5, 44.0 ppm.

4-(4-Fluoro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo-[3,4-*c*]carbazol-3(6*H*)-one (26d): 0.44 g (89%). M.p. 296–298 °C. IR (KBr): $\tilde{\nu}$ = 3340, 1654, 1562, 1375, 1177 cm^{-1}. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.74 (s, 1 H, NH), 8.37 (d, J = 8.4 Hz, 1 H, ArH), 8.24 (s, 1 H, ArH), 8.13 (d, J = 7.8 Hz, 1 H, ArH), 8.00 (d, J = 7.5 Hz, 1 H, ArH), 7.93 (d, J = 7.5 Hz, 2 H, ArH), 7.82–7.77 (m, 1 H, ArH), 7.72–7.65 (m, 3 H, ArH), 7.57–7.50 (m, 3 H, ArH), 4.90 (d, J = 19.2 Hz, 1 H, CH_2), 4.79 (d, J = 18.3 Hz, 1 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.8, 149.1 (d, J = 9.0 Hz), 139.1 (d, J = 5.4 Hz), 138.1, 136.2, 135.2, 134.6 (d, J = 8.1 Hz), 133.7, 129.9, 129.2, 128.5, 126.3, 125.1, 124.0, 122.7, 120.6, 120.3, 114.7 (d, J = 11.3 Hz), 111.6 (d, J = 27.4 Hz), 43.9 ppm.

4-(5-Fluoro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo-[3,4-*c*]carbazol-3(6*H*)-one (26e): 0.43 g (88%). M.p. 297–299 °C. IR (KBr): $\tilde{\nu}$ = 3340, 1654, 1562, 1375, 1177 cm^{-1}. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.73 (s, 1 H, NH), 8.35 (d, J = 8.4 Hz, 1 H, ArH), 8.30 (dd, J_1 = 5.1, J_2 = 9 Hz, 1 H, ArH), 8.26 (s, 1 H, ArH), 8.00 (d, J = 7.5 Hz, 1 H, ArH), 7.93 (d, J = 7.5 Hz, 2 H, ArH), 7.72–7.64 (m, 2 H, ArH), 7.62–7.51 (m, 5 H, ArH), 4.90 (d, J = 18.6 Hz, 1 H, CH_2), 4.79 (d, J = 18.6 Hz, 1 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.7, 145.1, 139.1, 138.9, 138.0, 136.2, 136.1, 133.4, 129.8, 128.6, 127.1 (d, J = 10.3 Hz), 126.4, 125.1, 125.0, 123.9, 122.7, 120.7, 119.6 (d, J = 24.5 Hz), 116.0 (d, J = 23.2 Hz), 114.7, 114.4, 44.0 ppm.

4-(5-Chloro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo-[3,4-*c*]carbazol-3(6*H*)-one (26f): 0.46 g (90%). M.p. 304–308 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.71 (s, 1 H, NH), 8.35 (d, J = 8.4 Hz, 1 H, ArH), 8.25–8.21 (m, 2 H, ArH), 7.99 (d, J = 7.5 Hz, 1 H, ArH), 7.92 (d, J = 7.5 Hz, 2 H, ArH), 7.81 (d, J = 8.7 Hz, 1 H, ArH), 7.71–7.64 (m, 3 H, ArH), 7.56–7.48 (m, 3 H, ArH), 4.84 (q, J = 31.5 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]-DMSO): δ = 168.7, 147.3, 139.0 (d, J = 7.1 Hz), 138.1, 137.7, 136.2, 135.1, 134.9, 133.1, 132.1, 129.8, 129.1, 128.5, 126.3, 125.8, 125.0 (d, J = 5.05 Hz), 123.9, 122.6, 120.7, 114.6 (d, J = 21.4 Hz), 43.9 ppm.

4-(5-Bromo-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo-[3,4-*c*]carbazol-3(6*H*)-one (26g): 0.47 g (83%). M.p. 297–299 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.75 (s, 1 H, NH), 8.35 (d, J = 8.4 Hz, 1 H, ArH), 8.25 (s, 1 H, ArH), 8.14 (d, J = 9.0 Hz, 1 H, ArH), 8.01–7.84 (m, 4 H, ArH), 7.84 (s, 1 H, ArH), 7.72–7.64 (m, 2 H, ArH), 7.57–7.48 (m, 3 H, ArH), 4.85 (q, J = 32.2 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 167.2, 146.2, 137.4 (d, J = 7.0 Hz), 136.5, 134.6, 133.6, 133.4 (d, J = 4.0 Hz), 131.5, 130.6, 128.3, 127.0, 125.2, 124.8, 124.3, 123.5, 122.4, 121.1, 119.2, 113.0 (d, J = 20.1 Hz), 42.4 ppm. $C_{26}H_{16}BrN_3O_5S$ (562.39): calcd. C 55.53, H 2.87, N 7.47; found C 55.71, H 2.63, N 7.29.

4-(4,5-Dichloro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26h): 0.48 g (88%). M.p. 303–305 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.76 (s, 1 H, NH), 8.48 (s, 1 H, ArH), 8.33 (d, J = 8.4 Hz, 1 H, ArH), 8.27 (s, 1 H, ArH), 8.00–7.91 (m, 4 H, ArH), 7.66 (q, J = 15.7 Hz, 2 H, ArH), 7.55–7.51 (m, 3 H, ArH), 4.83 (q, J = 32.5 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.7, 147.4, 139.0 (d, J = 4.5 Hz), 138.1, 136.1 (d, J = 10.4 Hz), 135.1, 133.9, 133.0, 132.0, 131.5, 129.8, 128.6, 126.4, 125.7, 125.0, 123.8, 122.7, 120.9, 114.6 (d, J = 13.5 Hz), 44.0 ppm.

4-(5-Chloro-4-fluoro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26i): 0.48 g (90%). M.p. 306–308 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.77 (s, 1 H, NH), 8.37 (d, J = 9.3 Hz, 1 H, ArH), 8.29 (s, 1 H, ArH), 8.01–7.92 (m, 4 H, ArH), 7.68 (q, J = 7.5 Hz, 2 H, ArH), 7.54–7.51 (m, 3 H, ArH), 4.85 (q, J = 33.0 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.5, 158.0, 154.6, 147.5, 147.4, 139.0 (d, J = 6.1 Hz), 138.0, 136.1, 135.1, 134.0, 132.2, 130.3 (d, J = 4.2 Hz), 128.0, 124.9, 124.6, 123.9, 122.7, 120.8, 114.6 (d, J = 5.3 Hz), 113.1 (d, J = 26.4 Hz), 43.9 ppm.

4-(4-Chloro-5-fluoro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26j): 0.45 g (85%). M.p. 302–304 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.80 (s, 1 H, NH), 8.53 (d, J = 6.9 Hz, 1 H, ArH), 8.36 (d, J = 8.4 Hz, 1 H, ArH), 8.30 (s, 1 H, ArH), 8.01 (d, J = 7.8 Hz, 1 H, ArH), 7.95 (d, J = 7.8 Hz, 2 H, ArH), 7.84 (d, J = 9.3 Hz, 1 H, ArH), 7.69 (q, J = 7.6 Hz, 2 H, ArH), 7.58–7.49 (m, 3 H, ArH), 4.84 (q, J = 19.0 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 160.8, 157.4, 145.1, 139.0 (d, J = 2.2 Hz), 138.0, 136.1, 135.2, 134.5 (d, J = 9.0 Hz), 132.3, 128.6, 126.7, 126.4, 125.0 (d, J = 6.0 Hz), 123.8, 122.7, 120.9, 120.1, 119.9, 114.6, 114.4, 44.0 ppm.

4-(5-Bromo-4-fluoro-2-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26k): 0.50 g (88%). M.p. 305–307 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.77 (s, 1 H, NH), 8.36–8.28 (m, 3 H, ArH), 8.06–7.92 (m, 4 H, ArH), 7.72–7.65 (m, 2 H, ArH), 7.57–7.48 (m, 3 H, ArH), 4.85 (q, J = 32.7 Hz, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.7, 159.2, 155.9, 148.2, 148.1, 139.0 (d, J = 7.0 Hz), 138.0, 136.8, 136.1, 135.1, 132.2, 130.4 (d, J = 4.1 Hz), 129.8, 128.5, 126.3, 125.0 (d, J = 4.0 Hz), 123.9, 122.7, 120.8, 114.7, 114.6, 113.8 (d, J = 21.0 Hz), 112.6 (d, J = 28.0 Hz), 43.9 ppm.

4-(2,3-Dichloro-6-nitrophenyl)-6-(phenylsulfonyl)-1,2-dihydropyrrolo[3,4-*c*]carbazol-3(6*H*)-one (26l): 0.48 g (88%). M.p. 301–303 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 8.76 (s, 1 H, NH), 8.41 (d, J = 8.4 Hz, 1 H, ArH), 8.27 (s, 1 H, ArH), 8.21 (d, J = 9.0 Hz, 1 H, ArH), 8.08–8.00 (m, 2 H, ArH), 7.88 (d, J = 7.8 Hz, 2 H, ArH), 7.72–7.49 (m, 5 H, ArH), 4.89 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 168.3, 148.2, 138.9 (d, J = 21.6 Hz),

138.2, 136.8, 135.9, 135.1, 133.8, 133.3, 130.6, 130.1, 129.7, 128.7, 126.2, 126.0, 125.1, 123.8 (d, J = 14.1 Hz), 122.8, 121.4, 114.7 (d, J = 11.3 Hz), 44.1 ppm. $C_{26}H_{15}Cl_2N_3O_5S$ (552.38): calcd. C 56.53, H 2.74, N 7.61; found C 56.78, H 2.48, N 7.84.

General Procedure for Triethyl Phosphite-Mediated Nitrene Insertion of 2′-Nitroaryl Carbazolamides 26a–26k: A mixture of 2′-nitroarylcarbazole (**26a**–**26k**; 0.1 mmol) and triethyl phosphite (2 mL) in *o*-DCB (5 mL) was heated to reflux under N_2 for 12 h. After consumption of the nitro compound (monitored by TLC), the solvent was removed under reduced pressure and the solid obtained was washed with hexane (5 mL) to afford *N*-protected indolo carbazoles **27a**–**27e**. The crude product **27f**–**27k** was used in the next step (hydrolysis) without further characterization.

12-(Phenylsulfonyl)-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo-[3,4-*c*]carbazol-5-one (27a): Brown solid. 0.04 g (89%). M.p. 300–302 °C. IR (KBr): $\tilde{\nu}$ = 3410, 3345, 1652, 1365, 1172 cm^{-1}. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.28 (br. s, 1 H, NH), 9.38 (d, J = 8.1 Hz, 1 H, ArH), 8.85 (s, 1 H, NH), 8.39 (d, J = 8.4 Hz, 1 H, ArH), 7.97 (d, J = 8.1 Hz, 1 H, ArH), 7.90 (d, J = 7.8 Hz, 1 H, ArH), 7.63 (t, J = 7.2 Hz, 1 H, ArH), 7.55–7.50 (m, 5 H, ArH), 7.35–7.26 (m, 3 H, ArH), 4.90 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 170.8, 139.8, 138.5, 134.9, 134.8, 130.8, 129.5, 127.7, 127.4, 126.9, 126.4, 126.3, 125.8, 125.5, 125.0, 124.9, 121.8, 121.4, 120.1, 119.5, 116.5, 112.3, 45.0 ppm. HRMS (ESI): calcd. for $C_{26}H_{17}N_3NaO_3S$ $[M + Na]^+$ 474.0888; found 474.5312.

2,3-Dimethoxy-12-(phenylsulfonyl)-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (27b): Brown solid. 0.04 g (85%). M.p. 294–296 °C. IR (KBr): $\tilde{\nu}$ = 3409, 3340, 1648, 1371, 1182 cm^{-1}. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.04 (br. s, 1 H, NH), 8.93 (s, 1 H, ArH), 8.74 (s, 1 H, NH), 8.36 (d, J = 8.1 Hz, 1 H, ArH), 7.84 (d, J = 7.5 Hz, 1 H, ArH), 7.60–7.49 (m, 6 H, ArH), 7.33 (m, 2 H, ArH), 4.85 (s, 2 H, CH_2), 3.92 (s, 3 H, OMe), 3.87 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 171.1, 150.1, 144.1, 138.1, 135.4, 135.0, 134.8, 130.4, 129.5, 127.0, 126.9, 126.3, 125.7, 124.8, 123.5, 121.5, 120.1, 118.3, 116.3, 113.7, 107.5, 95.3, 56.0, 55.5, 45.1 ppm. $C_{28}H_{21}N_3O_5S$ (511.54): calcd. C 65.74, H 4.14, N 8.21; found C 65.47, H 4.39, N 8.48.

2-Chloro-12-(phenylsulfonyl)-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]-pyrrolo[3,4-*c*]carbazol-5-one (27c): Brown solid. 0.04 g (90%). M.p. > 310 °C. IR (KBr): $\tilde{\nu}$ = 3405, 3322, 1682, 1376, 1182 cm^{-1}. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.39 (br. s, 1 H, NH), 9.34 (d, J = 8.1 Hz, 1 H, ArH), 8.91 (s, 1 H, NH), 8.37 (d, J = 7.5 Hz, 1 H, ArH), 8.06 (s, 1 H, ArH), 7.89 (d, J = 6.6 Hz, 1 H, ArH), 7.63–7.50 (m, 6 H, ArH), 7.35–7.32 (m, 2 H, ArH) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 170.7, 140.3, 138.4, 134.9, 134.8, 131.3, 130.9, 129.6, 128.0, 127.6, 126.7, 126.6, 126.4, 125.8, 124.9, 124.7, 121.8, 120.4, 120.2, 119.8, 118.9, 116.5, 112.0, 45.1 ppm.

2-Fluoro-12-(phenylsulfonyl)-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]-pyrrolo[3,4-*c*]carbazol-5-one (27d): Brown solid. 0.04 g (89%). M.p. > 310 °C. IR (KBr): $\tilde{\nu}$ = 3411, 3320, 1683, 1312, 1172 cm^{-1}. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.41 (br. s, 1 H, NH), 9.39–9.34 (m, 1 H, ArH), 8.89 (s, 1 H, NH), 8.38 (d, J = 7.5 Hz, 1 H, ArH), 7.90 (d, J = 7.5 Hz, 1 H, ArH), 7.78 (d, J = 9.9 Hz, 1 H, ArH), 7.63 (t, J = 7.8 Hz, 1 H, ArH), 7.53–7.51 (m, 3 H, ArH), 7.36–7.31 (m, 3 H, ArH), 7.17–7.11 (m, 1 H, ArH), 4.89 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 170.8, 140.6 (d, J = 13.6 Hz), 138.4, 134.8, 131.2, 130.7, 129.6, 128.8, 128.2, 127.4, 127.0 (d, J = 9.8 Hz), 126.8, 126.4, 125.8, 124.9, 124.5, 121.8, 119.9, 119.2, 118.3, 116.5, 107.1 (d, J = 24.13 Hz), 98.7, 98.4 (d, J = 26.4 Hz) ppm. $C_{26}H_{16}FN_3O_3S$ (469.49): calcd. C 66.51, H 3.44, N 8.95; found C 66.78, H 3.71, N 7.67.

3-Fluoro-12-(phenylsulfonyl)-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]-pyrrolo[3,4-*c*]carbazol-5-one (27e): Brown solid. 0.04 g (92%). M.p. > 310 °C. IR (KBr): $\tilde{\nu}$ = 3412, 3340, 1673, 1381, 1182 cm^{-1}. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.39 (br. s, 1 H, NH), 9.15–9.11 (m, 1 H, ArH), 8.95 (s, 1 H, NH), 8.40 (d, J = 8.4 Hz, 1 H, ArH), 8.01 (dd, J_1 = 4.8, J_2 = 8.7 Hz, 1 H, ArH), 7.93 (d, J = 7.8 Hz, 1 H, ArH), 7.65 (t, J = 8.1 Hz, 1 H, ArH), 7.56–7.40 (m, 6 H, ArH), 4.92 (s, 2 H, CH_2) ppm. $C_{26}H_{16}FN_3O_3S$ (469.49): calcd. C 66.51, H 3.44, N 8.95; found C 66.62, H 3.51, N 9.12.

General Procedure for Hydrolysis Reaction of Indolocarbazoles 27a–27k: To a suspension of *N*-protected indolo carbazoles **27a**–**27k** (0.5 mmol) in MeOH (5 mL) and THF (5 mL), K_2CO_3 (1.5 mmol) was added and the reaction mixture was heat to reflux for 10 h. After completion of the reaction (monitored by TLC), the solvent was removed under reduced pressure and the resulting residue was poured over crushed ice (25 g) that contained dilute HCl (5 mL). The solid formed was filtered and washed with water and dried to afford indolocarbazoles **28a**–**28k** as brown solids.

6,7,12,13-Tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (28a): 0.14 g (91%). M.p. > 310 °C. ^1H NMR (300 MHz, [D$_6$]-DMSO): δ = 11.52 (br. s, 1 H, NH), 11.35 (br. s, 1 H, NH), 9.24 (d, J = 7.5 Hz, 1 H, ArH), 8.51 (s, 1 H, NH), 8.06 (d, J = 7.8 Hz, 1 H, ArH), 7.80 (d, J = 8.7 Hz, 1 H, ArH), 7.74 (d, J = 7.8 Hz, 1 H, ArH), 7.52–7.41 (m, 2 H, ArH), 7.32 (t, J = 7.4 Hz, 1 H, ArH), 7.24 (t, J = 7.5 Hz, 1 H, ArH), 4.96 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.4, 139.2, 139.1, 132.9, 127.8, 125.3, 125.2, 124.99 (2 C), 127.8, 122.5, 121.1, 119.9, 118.929, 118.8, 115.6, 114.1, 111.9, 111.3, 45.3 ppm. HRMS (FAB$^+$): calcd. for $C_{20}H_{13}N_3O$ $[M]^+$ 311.1059; found 311.1063.

2,3-Dimethoxy-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]-carbazol-5-one (28b): 0.16 g (86%). M.p. > 310 °C. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.07 (br. s, 1 H, NH), 10.63 (s, 1 H, NH), 8.90 (s, 1 H, NH), 7.90 (d, J = 7.5 Hz, 1 H, ArH), 7.66 (s, 1 H, ArH), 7.63–7.60 (m, 2 H, ArH), 7.43 (t, J = 7.5 Hz, 1 H, ArH), 7.28 (m, 1 H, ArH), 7.09 (s, 1 H, ArH), 4.93 (s, 2 H, CH_2), 4.03 (s, 3 H, OMe), 4.00 (s, 3 H, OMe) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]-DMSO): δ = 172.6, 149.0, 143.6, 139.1, 134.3, 132.4, 128.1, 124.9, 124.5, 122.7, 120.8, 119.6, 117.9, 116.2, 115.1, 112.9, 111.6, 107.9, 94.7, 56.1, 55.6. 45.3 ppm. HRMS (FAB$^+$): calcd. for $C_{22}H_{17}N_3O_3$ $[M]^+$ 371.1270; found 371.1260.

2-Chloro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]-carbazol-5-one (28c): 0.15 g (88%). M.p. > 310 °C. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.70 (s, 1 H, NH), 11.55 (s, 1 H, NH), 9.20 (d, J = 8.7 Hz, 1 H, ArH), 8.55 (s, 1 H, NH), 8.31 (s, 1 H, ArH), 8.05 (d, J = 7.8 Hz, 1 H, ArH), 7.84 (s, 1 H, ArH), 7.78 (d, J = 8.1 Hz, 1 H, ArH), 7.48 (t, J = 7.5 Hz, 1 H, ArH), 7.34–7.24 (m, 2 H, ArH), 4.96 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 173.0, 139.5, 139.2, 133.5, 129.8, 127.5, 125.7, 125.4, 125.4, 122.0, 121.0, 120.8, 120.3, 119.3, 117.5, 114.7, 114.2, 111.7, 110.8, 45.4 ppm. HRMS (FAB$^+$): calcd. for $C_{20}H_{12}ClN_3O$ $[M]^+$ 345.0669; found 345.0660.

2-Fluoro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (28d): 0.15 g (91%). M.p. > 310 °C. ^1H NMR (300 MHz, [D$_6$]DMSO): δ = 11.55 (br. s, 1 H, NH), 11.45 (br. s, 1 H, NH), 9.25–9.20 (m, 1 H, ArH), 8.53 (s, 1 H, NH), 8.03 (d, J = 7.8 Hz, 1 H, ArH), 7.78 (d, J = 8.1 Hz, 1 H, ArH), 7.57 (d, J = 10.2 Hz, 1 H, ArH), 7.47 (t, J = 7.5 Hz, 1 H, ArH), 7.30 (t, J = 7.5 Hz, 1 H, ArH), 7.09 (t, J = 9.2 Hz, 1 H, ArH), 4.96 (s, 2 H, CH_2) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.4, 139.6 (d, J = 12.8 Hz), 139.2, 133.1, 127.7, 126.5, 126.3, 125.9, 125.0, 122.5, 121.1, 119.9, 119.6, 118.5, 115.3, 114.1, 111.9, 107.1 (d, J =

23.6 Hz), 97.7 (d, J = 26.2 Hz), 45.3 ppm. HRMS (FAB$^+$): calcd. for $C_{20}H_{12}FN_3O$ [M]$^+$ 329.0964; found 329.0973.

3-Fluoro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (28e): 0.15 g (91%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.71 (br. s, 1 H, NH), 11.53 (br. s, 1 H, NH), 8.96 (d, J = 10.2 Hz, 1 H, ArH), 8.55 (br. s, 1 H, NH), 8.05 (d, J = 7.5 Hz, 1 H, ArH), 7.80–7.71 (m, 2 H, ArH), 7.48 (t, J = 7.2 Hz, 1 H, ArH), 7.34–7.29 (m, 2 H, ArH), 4.97 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.3, 139.2, 135.7, 135.0, 133.0, 127.8, 126.7, 125.1, 122.5, 121.1, 120.0, 119.6, 118.8, 114.4, 112.8 (d, J = 26 Hz), 112.3 (d, J = 9.6 Hz), 112.0, 109.7 (d, J = 24.8 Hz), 45.4 ppm. HRMS (FAB$^+$): calcd. for $C_{20}H_{12}FN_3O$ [M]$^+$ 329.0964; found 329.0965.

3-Chloro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (28f): 0.14 g (83%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.57 (s, 1 H, NH), 11.50 (s, 1 H, NH), 9.27 (s, 1 H, ArH), 8.55 (s, 1 H, NH), 8.05 (d, J = 7.8 Hz, 1 H, ArH), 7.79 (t, J = 8.8 Hz, 2 H, ArH), 7.52–7.42 (m, 2 H, ArH), 7.32 (t, J = 7.3 Hz, 1 H, ArH), 4.98 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.2, 139.2, 137.5, 133.3, 127.7, 126.2, 125.1, 124.7, 124.0, 123.8, 123.0, 122.4, 121.1, 120.0, 118.8, 114.6 (d, J = 3.3 Hz), 112.9, 112.0, 45.3 ppm. HRMS (EI): calcd. for $C_{20}H_{12}ClN_3O$ [M]$^+$ 345.0669; found 345.0650.

3-Bromo-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]carbazol-5-one (28g): 0.17 g (88%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.60 (s, 1 H, NH), 11.54 (s, 1 H, NH), 9.41 (s, 1 H, ArH), 8.58 (s, 1 H, NH), 8.06 (d, J = 6.0 Hz, 1 H, ArH), 7.81 (d, J = 7.2 Hz, 1 H, ArH), 7.73 (d, J = 7.8 Hz, 1 H, ArH), 7.56–7.50 (m, 2 H, ArH), 7.32–7.30 (m, 1 H, ArH), 4.98 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.2, 139.2, 137.7, 133.3, 127.6, 127.2, 127.0, 126.0, 125.1, 124.5, 122.4, 121.1, 120.0, 118.8, 114.6, 114.5, 113.4, 112.0, 110.9, 45.3 ppm. HRMS (EI): calcd. for $C_{20}H_{12}BrN_3O$ [M]$^+$ 389.0164; found 389.0160.

2,3-Dichloro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo[3,4-*c*]-carbazol-5-one (28h): 0.17 g (89%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.68 (s, 1 H, NH), 11.56 (s, 1 H, NH), 9.41 (s, 1 H, ArH), 8.62 (s, 1 H, NH), 8.07–7.80 (m, 3 H, ArH), 7.51–7.33 (m, 2 H, ArH), 4.98 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.1, 139.2, 137.9, 133.6, 127.5, 126.9, 126.5, 125.5, 125.3, 122.7, 122.3, 121.2, 120.9, 120.0, 118.7, 114.9, 114.1, 113.1, 112.0, 45.4 ppm. HRMS (EI): calcd. for $C_{20}H_{11}Cl_2N_3O$ [M]$^+$ 379.0279; found 379.0270.

3-Chloro-2-fluoro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo-[3,4-*c*]carbazol-5-one (28i): 0.16 g (88%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.59 (s, 2 H, NH), 9.35 (d, J = 8.1 Hz, 1 H, NH), 8.56 (s, 1 H, NH), 8.03 (d, J = 7.5 Hz, 1 H, ArH), 7.78 (m, 2 H, ArH), 7.49 (t, J = 7.3 Hz, 1 H, ArH), 7.31 (m, 1 H, ArH), 4.95 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.2, 156.7, 153.5, 139.24, 137.3 (d, J = 11.6 Hz), 133.4, 127.5, 126.3, 125.5, 125.2, 122.3, 121.2, 120.0, 119.9, 118.4, 114.4 (d, J = 8.6 Hz), 111.9, 110.5 (d, J = 19.4 Hz), 99.4 (d, J = 25.6 Hz) ppm. HRMS (EI): calcd. for $C_{20}H_{11}ClFN_3O$ [M]$^+$ 363.0575; found 363.0570.

2-Chloro-3-fluoro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo-[3,4-*c*]carbazol-5-one (28j): 0.16 g (88%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.75 (s, 1 H, NH), 11.56 (s, 1 H, NH), 9.10 (d, J = 10.2 Hz, 1 H, ArH), 8.59 (s, 1 H, NH), 8.03 (d, J = 7.5 Hz, 1 H, ArH), 7.9 (d, J = 6.0 Hz, 1 H, ArH), 7.78 (d, J = 7.8 Hz, 1 H, ArH), 7.49 (t, J = 7.2 Hz, 1 H, ArH), 7.31 (t, J = 6.9 Hz, 1 H, ArH), 4.95 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.2, 152.5, 149.4, 139.2, 135.5, 133.4, 127.6, 126.8, 125.2, 122.3, 121.7 (d, J = 9.8 Hz), 121.2, 120.0, 118.6, 116.6 (d, J = 21.1 Hz), 114.8, 114.7, 112.5, 111.9, 110.8 (d, J = 24.8 Hz), 45.37 ppm. $C_{20}H_{11}ClFN_3O$ (363.77): calcd. C 66.03, H 3.05, N 11.55; found C 65.71, H 3.31, N 11.79.

3-Bromo-2-fluoro-6,7,12,13-tetrahydro-5*H*-indolo[2,3-*a*]pyrrolo-[3,4-*c*]carbazol-5-one (28k): 0.17 (85%). M.p. > 310 °C. ^{1}H NMR (300 MHz, [D$_6$]DMSO): δ = 11.63 (s, 2 H, NH), 9.48 (d, J = 7.2 Hz, 1 H, ArH), 8.59 (s, 1 H, NH), 8.04 (d, J = 7.5 Hz, 1 H, ArH), 7.79 (d, J = 9.0 Hz, 2 H, ArH), 7.49 (t, J = 7.3 Hz, 1 H, ArH), 7.32 (d, J = 7.3 Hz, 1 H, ArH), 4.96 (s, 2 H, CH$_2$) ppm. ^{13}C NMR (75.4 MHz, [D$_6$]DMSO): δ = 172.2, 157.5, 154.3, 139.2, 138.5 (d, J = 11.7 Hz), 133.5, 128.3, 127.5, 126.3, 125.2, 122.3, 121.2, 120.7, 120.0, 118.4, 114.5, 114.2, 111.9, 99.3 (d, J = 27.1 Hz), 98.2 (d, J = 22.6 Hz), 45.4 ppm. HRMS (EI): calcd. for $C_{20}H_{11}BrFN_3O$ [M]$^+$ 407.0070; found 407.0070.

Ethyl (*E*)-3-[3-(2-Nitrostyryl)-1-(phenylsulfonyl)-1*H*-indol-2-yl]-acrylate (30a): To a solution of phosphonate ester **29**[27] (1.0 g, 1.97 mmol) in dry DMF, K_2CO_3 (0.54 g, 3.95 mmol) and 2-nitrobenzaldehyde (0.32 g, 2.17 mmol) were added and the reaction mixture was stirred at room temperature for 14 h. After completion of the reaction (monitored by TLC), it was poured over crushed ice (30 g) that contained conc. HCl (8 mL). The crude product was then extracted with EtOAc (2 × 20 mL) and dried (Na_2SO_4). The solvent was removed under reduced pressure and the crude product was purified by column chromatography (1% EtOAc/hexane) gave compound **30a** as a yellow solid. 0.75 g (75%). M.p. 158–160 °C. ^{1}H NMR (300 MHz, CDCl$_3$): δ = 8.26 (s, 1 H, ArH), 8.22–8.20 (m, 1 H, ArH), 7.93 (d, J = 8.1 Hz, 1 H, ArH), 7.87 (d, J = 7.8 Hz, 1 H, ArH), 7.68–7.63 (m, 4 H, ArH), 7.56 (t, J = 7.5 Hz, 1 H, ArH), 7.47–7.29 (m, 6 H, ArH), 6.96 (d, J = 16.5 Hz, 1 H, ArH), 6.06 (d, J = 15.9 Hz, 1 H, ArH), 4.27 (q, J = 7.2 Hz, 2 H, OCH$_2$), 1.32 (t, J = 7.2 Hz, 3 H, CH$_3$) ppm. ^{13}C NMR (75.4 MHz, CDCl$_3$): δ = 165.8, 147.6, 137.6, 137.4, 134.2, 134.0, 133.8, 133.5, 133.0, 129.2, 128.4, 128.2, 128.0, 127.9, 126.8, 126.7, 125.6, 125.0, 124.7, 123.2, 121.3, 115.3, 61.0, 14.3 ppm.

Ethyl (*E*)-3-[3-(5-Fluoro-2-nitrostyryl)-1-(phenylsulfonyl)-1*H*-indol-2-yl]acrylate (30b): The Wittig–Horner reaction of phosphonate ester **29**[27] (1.0 g, 1.97 mmol) with 5-fluoro-2-nitrobenzaldehyde (0.36 g, 2.17 mmol) by means of a procedure similar to that for the production of **30a** afforded **30b** as a yellow solid. 0.80 g (78%). M.p. 156–158 °C. ^{1}H NMR (300 MHz, CDCl$_3$): δ = 8.33 (d, J = 6.6 Hz, 1 H, ArH), 8.30 (s, 1 H, ArH), 8.12 (q, J = 5.1 Hz, 1 H, ArH), 7.95 (d, J = 7.8 Hz, 1 H, ArH), 7.81–7.76 (m, 3 H, ArH), 7.58–7.40 (m, 6 H, ArH), 7.16–7.13 (m, 1 H, ArH), 7.04 (d, J = 16.5 Hz, 1 H, ArH), 6.13 (d, J = 15.9 Hz, 1 H, ArH), 4.37 (q, J = 7.2 Hz, 2 H, OCH$_2$), 1.42 (t, J = 7.0 Hz, 3 H, CH$_3$) ppm. ^{13}C NMR (75.4 MHz, CDCl$_3$): δ = 165.7, 164.5 (d, J = 190.0 Hz), 143.7, 137.7, 137.3, 136.4 (d, J = 9.0 Hz), 134.5, 134.3, 133.7, 129.3, 128.1, 128.0, 126.9 (d, J = 3.0 Hz), 126.7, 126.0 (d, J = 6.7 Hz), 125.0, 122.6, 121.1, 115.5, 115.3, 115.2, 114.5 (d, J = 24.1 Hz), 61.1, 14.3 ppm. $C_{27}H_{21}FN_2O_6S$ (520.52): calcd. C 62.30, H 4.07, N 5.38; found C 62.56, H 3.88, N 5.21.

Ethyl 3-(2-Nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-2-carboxylate (31a): To a solution of divinyl compound **30a** (0.5 g) in dry xylenes (10 mL), 10% Pd/C (0.2 g) was added. The reaction mixture was heated to reflux for 24 h. Then, the reaction mixture was filtered through a Celite pad and washed with hot xylenes (10 mL). The combined filtrate was concentrated under reduced pressure and the resulting crude product was triturated with MeOH (3 mL) to afford carbazole **31a** as a pale yellow solid. 0.45 g (92%). M.p. 178–180 °C. ^{1}H NMR (300 MHz, CDCl$_3$): δ = 9.00 (s, 1 H, ArH),

8.29 (d, J = 8.4 Hz, 1 H, ArH), 8.06 (d, J = 8.1 Hz, 1 H, ArH), 7.83–7.81 (m, 3 H, ArH), 7.67 (s, 1 H, ArH), 7.61–7.42 (m, 4 H, ArH), 7.35–7.29 (m, 4 H, ArH), 4.11 (q, J = 6.9 Hz, 2 H, OCH_2), 1.09 (t, J = 7.0 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 166.2, 148.3, 139.7, 137.6, 137.5, 137.4, 135.5, 134.1, 132.6, 131.7, 129.2, 129.1, 128.8, 128.2, 128.0, 126.5, 125.1, 124.3, 124.0, 121.2, 120.8, 117.3, 115.2, 61.2, 13.8 ppm. $C_{27}H_{20}N_2O_6S$ (500.52): calcd. C 64.79, H 4.03, N 5.60; found C 64.92, H 4.25, N 5.58.

Ethyl 3-(5-Fluoro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-2-carboxylate (31b): The procedure was similar to that for the production of **31a**. 0.46 g (93%). M.p. 180–182 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 8.99 (s, 1 H, ArH), 8.24 (d, J = 8.4 Hz, 1 H, ArH), 8.09 (dd, J_1 = 5.1, J_2 = 5.1 Hz, 1 H, ArH), 7.82–7.74 (m, 3 H, ArH), 7.64 (s, 1 H, ArH), 7.49–7.40 (m, 3 H, ArH), 7.37–7.25 (m, 2 H, ArH), 7.16–7.08 (m, 1 H, ArH), 6.96 (dd, J_1 = 2.7, J_2 = 2.7 Hz, 1 H, ArH), 4.12 (q, J = 6.6 Hz, 2 H, OCH_2), 1.11 (t, J = 7.2 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 165.8, 162.5, 144.4, 140.7 (d, J = 9.8 Hz), 139.6, 137.5, 134.6, 134.1, 129.2, 129.1, 128.9, 127.6, 126.8 (d, J = 9.8 Hz), 126.5, 124.9, 124.3, 120.8 (d, J = 4.5 Hz), 118.9, 118.6, 117.4, 115.2, 114.8, 61.3, 13.8 ppm. $C_{27}H_{19}FN_2O_6S$ (518.51): calcd. C 62.54, H 3.69, N 5.40; found C 62.73, H 3.52, N 5.61.

Triethyl Phosphite-Mediated Nitrene Insertion Reaction of 3-(2-Nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-2-carboxylate (31a): A mixture of 2′-nitroarylcarbazoles **31a** (0.2 g) and triethyl phosphite (2 mL) was heated to reflux under N_2 for 6 h. After consumption of **31a** (monitored by TLC), the reaction mixture poured over crushed ice (20 g) that contained conc. HCl (5 mL). It was then extracted with EtOAc (20 mL) and dried (Na_2SO_4). The solvent was removed under reduced pressure to afford a mixture of indolocarbazole **32a** and quinocarbazole **33a** in a 3:1 ratio. Careful separation by silica-gel column chromatography (5% EtOAc/hexane) gave quinocarbazole **33a**. Further elution gave indolocarbazole **32a**.

Data for indolocarbazole **32a**: Colorless solid. 0.11 g (60%). M.p. 225–227 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 12.14 (s, 1 H, NH), 8.78 (d, J = 7.8 Hz, 1 H, ArH), 8.77 (s, 1 H, ArH), 8.71 (d, J = 8.4 Hz, 1 H, ArH), 8.39 (d, J = 8.1 Hz, 1 H, ArH), 7.85 (d, J = 7.8 Hz, 2 H, ArH), 7.75–7.45 (m, 7 H, ArH), 7.27 (t, J = 7.6 Hz, 1 H, ArH), 4.58 (q, J = 7.0 Hz, 2 H, OCH_2), 1.49 (t, J = 7.0 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 167.1, 140.9, 137.9, 136.4, 135.1, 134.8, 133.3, 129.7, 127.8, 126.0, 124.7, 124.3, 124.1, 124.0, 122.4, 120.8, 119.6, 117.4, 114.7, 112.9, 111.5, 108.5, 61.2, 14.2 ppm. DEPT 135 (75.4 MHz, $CDCl_3$): δ = 134.8, 129.7, 127.8, 126.1, 126.0, 124.7, 124.1, 122.4, 119.6, 114.7, 111.5, 108.5, 61.2, 14.2 ppm. HRMS (EI): calcd. for $C_{27}H_{20}N_2O_4S$ $[M]^+$ 468.1144; found 468.1144.

6-Ethoxy-8-(phenylsulfonyl)-8*H*-indolo[2,3-*j*]phenanthridine (33a): Colorless solid. 0.03 g (20%). M.p. 190–192 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 9.30 (s, 1 H, NH), 8.34–8.29 (m, 3 H, ArH), 7.95 (dd, J_1 = 7.5, J_2 = 7.8 Hz, 2 H, ArH), 7.78 (d, J = 7.5 Hz, 2 H, ArH), 7.46–7.20 (m, 7 H, ArH), 4.64 (q, J = 7.0 Hz, 2 H, OCH_2), 1.63 (t, J = 7.2 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 152.3, 139.2, 138.2, 138.0, 137.7, 133.8, 129.0, 127.2, 127.0, 126.5, 125.5, 124.1, 123.5, 123.4, 123.0, 119.7, 119.4, 116.4, 115.4, 110.2, 103.4, 96.1, 63.5, 14.5 ppm. DEPT 135 (75.4 MHz, $CDCl_3$): δ = 132.7, 128.0, 126.2, 126.0, 125.4, 123.1, 122.4, 118.7, 118.4, 115.3, 114.3, 109.2, 102.4, 62.4, 13.4 ppm. HRMS (EI): calcd. for $C_{27}H_{20}N_2O_3S$ $[M]^+$ 452.1195; found 452.1194.

Triethyl Phosphite-Mediated Nitrene Insertion Reaction of Ethyl 3-(5-Fluoro-2-nitrophenyl)-9-(phenylsulfonyl)-9*H*-carbazole-2-carboxylate (31b): The reaction of 5-fluoro-2′-nitroarylcarbazole (**31b**; 0.2 g) with triethyl phosphite (2 mL) by using the procedure described above, followed by workup and column chromatographic separation, led to isolation of indolocarbazole **32b** and quinocarbazole **33b** in a 3:1 ratio.

Data for indolocarbazole **32b**: Colorless solid. 0.13 g (68%). M.p. 260–262 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 11.64 (s, 1 H, NH), 8.79 (s, 1 H, ArH), 8.60 (d, J = 7.5 Hz, 1 H, ArH), 8.50 (d, J = 10.8 Hz, 1 H, ArH), 8.35 (d, J = 8.4 Hz, 1 H, ArH), 7.76 (d, J = 7.5 Hz, 2 H, ArH), 7.58–7.27 (m, 6 H, ArH), 7.14 (t, J = 7.8 Hz, 1 H, ArH), 4.55 (q, J = 6.9 Hz, 2 H, OCH_2), 1.52 (t, J = 7.0 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 172.2, 160.3 (d, J = 190.0 Hz), 143.4, 142.5, 142.1, 140.6, 139.7, 139.0, 134.0, 132.3, 131.1, 129.4, 129.2 (d, J = 2.2 Hz), 127.2, 126.7 (d, J = 11.3 Hz), 122.7 (d, J = 4.5 Hz), 119.7, 118.7, 118.4 (d, J = 8.3 Hz), 116.7 (d, J = 9.8 Hz), 115.0 (d, J = 26.4 Hz), 114.3, 66.1, 19.3 ppm. DEPT 135 (75.4 MHz, $CDCl_3$): δ = 139.1, 134.0, 132.3, 131.1, 129.3, 127.2, 119.7, 118.6 (d, J = 26.6 Hz), 116.7 (d, J = 9.8 Hz), 115.0 (d, J = 25.6 Hz), 114.3, 66.1, 19.3 ppm. HRMS (EI): calcd. for $C_{27}H_{19}N_2O_4S$ $[M]^+$ 486.1050; found 486.1050.

6-Ethoxy-2-fluoro-8-(phenylsulfonyl)-8*H*-indolo[2,3-*j*]phenanthridine (33b): Colorless solid. 0.05 g (25%). M.p. 250–252 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 9.26 (s, 1 H, NH), 8.31–8.27 (m, 3 H, ArH), 7.91 (d, J = 7.5 Hz, 1 H, ArH), 7.78 (d, J = 8.1 Hz, 2 H, ArH), 7.60 (dd, J_1 = 2.1, J_2 = 2.1 Hz, 1 H, ArH), 7.46–7.09 (m, 6 H, ArH), 4.63 (q, J = 7.2 Hz, 2 H, OCH_2), 1.63 (t, J = 7.0 Hz, 3 H, CH_3) ppm. ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 159.5 (d, J = 241.2 Hz), 152.1, 139.2, 138.5 (d, J = 3.7 Hz), 137.8, 135.3, 133.8, 129.0, 127.2, 126.6, 126.1, 124.2, 123.0, 122.5 (d, J = 3.0 Hz), 119.8, 117.4 (d, J = 8.3 Hz), 115.3, 114.5, 114.1, 110.4, 105.7, 105.3, 103.4, 63.6, 14.4 ppm. DEPT 135 (75.4 MHz, $CDCl_3$): δ = 133.8, 129.0, 127.4, 126.4, 124.2, 119.8, 117.4 (d, J = 8.3 Hz), 115.3, 114.3 (d, J = 24.8 Hz), 110.5, 105.5 (d, J = 24.1 Hz), 103.4, 63.6, 14.4 ppm. HRMS (EI): calcd. for $C_{27}H_{19}N_2O_3S$ $[M]^+$ 470.1100; found 470.1100.

Experimental Procedure for CDK5/p25 Assay: The CDK5/p25 enzymatic reactions for indolocarbazoles were performed in duplicate in a 10 μL reaction volume by using an assay buffer of Tris (50 mM), pH 7.5, $MgCl_2$ (5 mM), *Brij*-35 (0.01%) in Proxiplate 384 Plus white plates (Perkin–Elmer). Appropriate concentrations (100, 33.33, 11.11, ... 0.000063 μM) of indolocarbazoles were pre-incubated for 30 min with CDK5-p25 enzyme (5 nM) and the enzymatic reactions were initiated by the addition of Lance Ultra ULight-MBP peptide (50 nM, Perkin–Elmer, TRF0109-M). Reactions were terminated after 30 min by addition of reaction termination and detection reagents (10 μL) that are composed of EDTA (10 mM) in 1X LANCE detection buffer and LANCE Ultra Eu-anti-phospho-MBP (2 nM, Perkin–Elmer, TRF0201-M), respectively. After incubation for 1 h at room temperature, the samples were read by using a multi-label plate reader (Envision, Perkin–Elmer).

Supporting Information (see footnote on the first page of this article): Copies of ^1H NMR, ^{13}C NMR, and DEPT 135 spectra of prepared compounds are provided.

Acknowledgments

The authors thank the Council of Scientific and Industrial Research (CSIR), New Delhi [02(0214)/14/EMR-II dt. 17/11/2014] for financial support. DST-FIST is thanked for the NMR facility. P. R. thanks the University Grants Commission (UGC) for his fellowship. Dr. Neelamegam Ramesh is thanked for CDK5/p25 kinase assay data.

[1] a) J. Bergman, *In Studies in Natural Product Chemistry*, Part A, Elsevier Science: New York, **1988**, *1*, p. 3; b) G. W. Gribble, S. J. Berthel, *Studies in Natural Product Chemistry* **1993**, *12*, p. 365; c) M. Prudhomme, *Curr. Pharm. Des.* **1997**, *3*, 265–290; d) U. Pindur, Y.-S. Kim, F. Mehrabani, *Curr. Med. Chem.* **1999**, *6*, 29–69; e) M. Prudhomme, *Curr. Med. Chem.* **2000**, *7*, 1189–1212; f) M. Prudhomme, *Eur. J. Med. Chem.* **2003**, *38*, 123–140; g) J. Bergman, T. Janosik, N. Wahlström, *Adv. Heterocycl. Chem.* **2001**, *80*, 1–71; h) C. Sánchez, C. Méndez, J. A. Salas, *Nat. Prod. Rep.* **2006**, *23*, 1007–1045; i) H.-J. Knölker, K. R. Reddy, *In The Alkaloids*; (Ed.: G. A. Cordell); Academic Press: Amsterdam, **2008**; vol. 65, p 1.

[2] S. Omura, Y. Iwai, A. Hirano, A. Nakagawa, J. Awaya, H. Tsuchiya, Y. Takahashi, R. J. Masuma, *J. Antibiot.* **1977**, *30*, 275–282.

[3] V. Rialet, L. Meijer, *Anticancer Res.* **1991**, *11*, 1581–1590.

[4] S. Omura, Y. Sasaki, Y. Iwai, H. Takeshima, *J. Antibiot.* **1995**, *48*, 535–548.

[5] a) S. Gandy, A. J. Czernik, P. Greengard, *Proc. Natl. Acad. Sci. USA* **1988**, *85*, 6218–6221; b) E. Masliah, G. M. Cole, L. A. Hansen, M. Mallory, T. Albright, R. D. Terry, T. J. Saitoh, *Neuroscience* **1991**, *11*, 2759–2767.

[6] B. Knüsel, F. Hefti, *J. Neurochem.* **1992**, *59*, 1987–1996.

[7] a) T. Meyer, U. Regenass, D. Fabbro, E. Alteri, J. Rosel, M. Muller, G. Caravatti, A. Matter, *Int. J. Cancer* **1989**, *43*, 851–856; b) K. Kawakami, H. Futami, J. Takahara, K. Yamaguchi, *Biochem. Biophys. Res. Commun.* **1996**, *219*, 778–783.

[8] J. A. Bush, B. H. Long, J. J. Catino, W. T. Bradner, K. J. Tomita, *Antibiot.* **1987**, *40*, 668–678.

[9] S. Nakanishi, K. Matsuda, K. Iwahashi, H. Kase, *J. Antibiot.* **1986**, *39*, 1066–1071.

[10] J. Koivunen, V. Aaltonen, S. Koskela, P. Lehenkari, M. Laato, J. Peltonen, *Cancer Res.* **2004**, *64*, 5693–5701.

[11] W. Steglich, *Pure Appl. Chem.* **1989**, *61*, 281–288.

[12] a) S.-M. Yang, R. Malaviya, L. J. Wilson, R. Argentieri, X. Chen, C. Yang, B. Wang, D. Cavender, W. V. Murray, *Bioorg. Med. Chem. Lett.* **2007**, *17*, 326–331; b) M. M. Faul, T. A. Engler, K. A. Sullivan, J. L. Grutsch, M. T. Clayton, M. J. Martinelli, J. M. Pawlak, M. LeTourneau, D. Scott Coffey, S. W. Pedersen, S. P. Kolis, K. Furness, S. Malhotra, R. S. Al-awar, J. E. Ray, *J. Org. Chem.* **2004**, *69*, 2967–2975; c) G. Zhu, S. E. Conner, X. Zhou, C. Shih, T. Li, B. D. Anderson, H. B. Brooks, R. M. Campbell, E. Considine, J. A. Dempsey, M. M. Faul, C. Ogg, B. Patel, R. M. Schultz, C. D. Spencer, *J. Med. Chem.* **2003**, *46*, 2027–2030; d) C. Sanchez-Martinez, C. Shih, M. M. Faul, G. Zhu, M. Paal, C. Somoza, T. Li, C. A. Kumrich, L. L. Winneroski, Z. Xun, H. B. Brooks, B. K. R. Patel, R. M. Schultz, T. B. Dehahn, C. D. Spencer, S. A. Watkins, E. Considine, J. A. Dempsey, C. A. Ogg, R. M. Campbell, B. A. Anderson, J. Wagner, *Bioorg. Med. Chem. Lett.* **2003**, *13*, 3835–3839.

[13] F. Russell, D. Harmody, P. J. McCarthy, S. A. Pomponi, A. E. Wright, *J. Nat. Prod.* **2013**, *76*, 1989–1992.

[14] a) P.-L. T. Boudreault, A. A. Virkar, Z. Bao, M. Leclerc, *Org. Electron.* **2010**, *11*, 1649–1659; b) E. Zhou, J. Cong, K. Tajima, K. Hashimoto, *Chem. Mater.* **2010**, *22*, 4890–4895; c) P.-L. Boudreault, S. Wakim, M. L. Tang, Y. Tao, Z. Bao, M. Leclerc, *J. Mater. Chem.* **2009**, *19*, 2921–2928; d) T. Qi, W. Qiu, Y. Liu, H. Zhang, X. Guo, Y. Liu, K. Lu, C. Du, G. Yu, D. Zhu, *J. Org. Chem.* **2008**, *73*, 4638–4643; e) T. Tsuchimoto, H. Matsubayashi, M. Kaneko, Y. Nagase, T. Maiyamura, E. Shirakawa, *J. Am. Chem. Soc.* **2008**, *130*, 15823–15835; f) P.-L. T. Boudreault, S. Wakim, N. Blovin, M. Simard, C. Tessier, Y. Tao, M. J. Leclerc, *J. Am. Chem. Soc.* **2007**, *129*, 9125–9136.

[15] H.-J. Knölker, K. R. Reddy, *Chem. Rev.* **2002**, *102*, 4303–4428.

[16] a) M. M. Faul, T. A. Engler, K. A. Sullivan, J. L. Grutsch, M. T. Clayton, M. J. Martinelli, J. M. Pawlak, M. LeTourneau, D. Scott Coffey, S. W. Pedersen, S. P. Kolis, K. Furness, S. Malhotra, R. S. Al-awar, J. E. Ray, *J. Org. Chem.* **2004**, *69*, 2967–2975; b) M. Reddy, S.-Y. Chen, B.-J. Uang, *Synthesis* **2003**, 497–500; c) S. P. Gaudêncio, M. M. M. Santos, A. M. Lobo, S. Prabhakar, *Tetrahedron Lett.* **2003**, *44*, 2577–2578; d) C. Sanchez-Martinez, M. M. Faul, C. Shih, K. A. Sullivan, J. L. Grutsch, J. T. Cooper, S. P. Kolis, *J. Org. Chem.* **2003**, *68*, 8008–8014; e) S. Routier, G. Coudert, J.-Y. Me′rour, D. H. Caignard, *Tetrahedron Lett.* **2002**, *43*, 2561–2564; f) S. Eils, E. Winterfeldt, *Synthesis* **1999**, 275–281; g) E. M. Beccalli, M. L. Gelmi, A. Marchesini, *Tetrahedron* **1998**, *54*, 6909–6918; h) J. T. Link, S. Raghavan, M. Gallant, S. J. Danishefsky, T. C. Chou, L. M. Ballas, *J. Am. Chem. Soc.* **1996**, *118*, 2825–2842; i) G. Xie, J. W. Lown, *Tetrahedron Lett.* **1994**, *35*, 5555–5558; j) J. Brüning, T. Hache, E. Winterfeldt, *Synthesis* **1994**, 25–27; k) L. Liu, B. Yang, T. J. Katz, M. K. Poindexter, *J. Org. Chem.* **1991**, *56*, 3769–3775.

[17] a) K. Wang, Z. Liu, *Synth. Commun.* **2010**, *40*, 144–150; b) S. Delarue-Cochin, I. McCort-Tranchepain, *Org. Biomol. Chem.* **2009**, *7*, 706–716; c) J. Wang, M. Rosingana, D. J. Watson, E. D. Dowdy, R. P. Discordia, N. Soundarajan, W.-L. Li, *Tetrahedron Lett.* **2001**, *42*, 8935–8937; d) G. E. Burtin, D. J. Madge, D. L. Selwood, *Heterocycles* **2000**, *53*, 2119–2122; e) M. M. Faul, L. L. Winneroski, C. A. Krumrich, *J. Org. Chem.* **1999**, *64*, 2465–2470; f) D. E. Zembower, H. Zhang, J. P. Lineswala, M. J. Kuffel, S. A. Aytes, M. M. Ames, *Bioorg. Med. Chem. Lett.* **1999**, *9*, 145–150; g) M. M. Faul, L. L. Winneroski, C. A. Krumrich, *J. Org. Chem.* **1998**, *63*, 6053–6058; h) M. Ohkubo, H. Kawamoto, T. Ohno, M. Nakano, H. Morishima, *Tetrahedron* **1997**, *53*, 585–592; i) M. Ohkubo, H. Kawamoto, T. Ohno, M. Nakano, H. Morishima, *Tetrahedron* **1996**, *52*, 8099–8112; j) M. G. Saulnier, D. B. Frennesson, M. S. Deshpande, D. M. Vyas, *Tetrahedron Lett.* **1995**, *36*, 7841–7844; k) W. Harris, C. H. Hill, E. Keech, P. Malsher, *Tetrahedron Lett.* **1993**, *34*, 8361–8364.

[18] a) B. Witulski, T. Schweikert, *Synthesis* **2005**, *12*, 1959–1966; b) J. D. Chisholm, D. L. Van Vranken, *J. Org. Chem.* **2000**, *65*, 7541–7553; c) J. Bergman, E. Koch, B. Pelcman, *J. Chem. Soc. Perkin Trans. 1* **2000**, 2609–2614; d) S. Mahboobi, E. Eibler, M. Koller, K. C. Sunil Kumar, A. Popp, *J. Org. Chem.* **1999**, *64*, 4697–4704; e) R. P. Joyce, J. A. Gainor, S. M. Weinreb, *J. Org. Chem.* **1987**, *52*, 1177–1185; f) P. D. Magnus, N. L. Sear, *Tetrahedron* **1984**, *40*, 2195–2197; g) S. M. Weinreb, R. S. Garigipati, J. A. Gainor, *Heterocycles* **1984**, *21*, 309–324.

[19] M. M. Faul, K. A. Sullivan, *Tetrahedron Lett.* **2001**, *42*, 271–274.

[20] a) J. L. Wood, B. M. Stoltz, H. J. Dietrich, D. A. Plum, D. J. Petsch, *J. Am. Chem. Soc.* **1997**, *119*, 9641; b) J. Bergmann, E. Koch, B. Pelcman, *Tetrahedron* **1995**, *51*, 5631–5642.

[21] a) G. Balaji, W. L. Shim, M. Parameswaran, S. Valiyaveettil, *Org. Lett.* **2009**, *11*, 4450–4453; b) D. Alonso, E. Caballero, M. Medarde, F. Tome, *Tetrahedron Lett.* **2005**, *46*, 4839–4841; c) A. W. Freeman, M. Urvoy, M. E. Criswell, *J. Org. Chem.* **2005**, *70*, 5014–5019; d) J. T. Kuethe, A. Wong, I. W. Davies, *Org. Lett.* **2003**, *5*, 3721–3723; e) M. Adeva, F. Buono, E. Caballero, M. Medarde, F. Tome, *Synlett* **2000**, 832–834; f) T. B. Lowinger, J. Chu, P. L. Spence, *Tetrahedron Lett.* **1995**, *36*, 8383–8386; g) C. J. Moody, K. F. Rahimtoola, B. Porter, B. C. Ross, *J. Org. Chem.* **1992**, *57*, 2105–2114; h) I. Hughes, W. P. Nolan, R. A. Raphael, *J. Chem. Soc. Perkin Trans. 1* **1990**, 2475–2480.

[22] a) L. J. Wilson, C. Yang, W. V. Murray, *Tetrahedron Lett.* **2007**, *48*, 7399; b) S. C. Pelly, C. J. Parkinson, W. A. L. van Otterlo, C. B. de Koning, *J. Org. Chem.* **2005**, *70*, 10474–10481.

[23] a) P. D. Magnus, C. Exon, N. L. Sear, *Tetrahedron* **1983**, *39*, 3725–3729; b) U. Pindur, Y.-S. Kim, *J. Heterocycl. Chem.* **1996**, *33*, 623–631; c) U. Pindur, Y.-S. Kim, *J. Heterocycl. Chem.* **1998**, *35*, 97–101; d) U. Pindur, Y.-S. Kim, D. Schollmeyer, *J. Heterocycl. Chem.* **1995**, *32*, 1335–1339; e) M. M. B. Marques, A. M. Lobo, S. Prabhakar, P. S. Branco, *Tetrahedron Lett.* **1999**, *40*, 3795–3796; f) A. P. Fonseca, A. M. Lobo, S. Prabhakar, *Tetrahedron Lett.* **1995**, *36*, 2689–2692; g) M. M. B. Marques, M. M. M. Santos, A. M. Lobo, S. Prabhakar, *Tetrahedron Lett.* **2000**, *41*, 9835–9838.

[24] a) J. Bergman, B. J. Pelcman, *J. Org. Chem.* **1989**, *54*, 824–828; b) G. W. Gribble, S. J. Berthel, *Tetrahedron* **1992**, *48*, 8869–8880.
[25] Y. Wada, H. Nagasaki, M. Tokuda, K. Orito, *J. Org. Chem.* **2007**, *72*, 2008–2014.
[26] G. Gobi Rajeshwaran, A. K. Mohanakrishnan, *Org. Lett.* **2011**, *13*, 1418–1421.
[27] A. K. Mohanakrishnan, P. C. Srinivasan, *J. Org. Chem.* **1995**, *60*, 1939–1946.
[28] J. S. Yadav, B. V. Subba Reddy, K. Praneeth, *Tetrahedron Lett.* **2008**, *49*, 199–202.
[29] S. Selvakumaran, P. C. Srinivasan, *Indian J. Chem. Sect. B* **1985**, *24*, 6–7.
[30] H. Suhana, P. C. Srinivasan, *Synth. Commun.* **2003**, *33*, 3097–3102.
[31] a) T. Kametani, K. Nyu, T. Yamanaka, H. Yagi, K. Ogaswara, *Tetrahedron Lett.* **1969**, *10*, 1027–1030; b) T. Kametani, K. Nyu, T. Yamanaka, H. Yagi, K. Ogaswara, *Chem. Pharm. Bull.* **1969**, *17*, 2093–2096; c) P. Raju, G. Gobi Rajeshwaran, M. Nandakumar, A. K. Mohanakrishnan, *Eur. J. Org. Chem.* **2015**, 3513–3523.
[32] a) L. Meijer, A. Borgne, O. Mulner, J. P. J. Chong, J. J. Blow, M. Inagaki, J.-G. Delcros, J.-P. Moulinoux, *Eur. J. Biochem.* **1997**, *243*, 527–536; b) M. Hajdúch, L. Havlíéek, J. Veselý, R. Novotný, V. Mihál, M. Strnad, *Adv. Exp. Med. Biol.* **1999**, *457*, 341–353.
[33] O. P. Mgbonyebi, J. Russo, I. H. Russo, *Cancer Res.* **1999**, *59*, 1903–1910.

Received: July 16, 2015
Published Online: October 1, 2015

