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A simple one-pot synthesis of functionalised 6-(indol-3-yl)-2,2′-bipyridine derivatives via multi-component reaction under neat condition

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ABSTRACT

A series of 4-aryl-6-(1*H*-indol-3-yl)-2,2-bipyridine-5-carbonitrile derivatives were synthesized via a one-pot multi-component reaction of aromatic aldehydes, 3-(cyanoacetyl)indole and 2-acetyl pyridine in ammonium acetate by conventional heating and microwave irradiation under solvent-free condition. Also a series of 6,6′-di(1*H*-indol-3-yl)-4,4′-diaryl-2,2′-bipyridine-5,5′-dicarbonitrile derivatives were synthesized using cinnamils, 3-(cyanoacetyl)indole and ammonium acetate. The methodology affords high yields of product at short reaction time.

The rapid assembly of molecular diversity is an important goal of synthetic organic chemistry and is one of the key paradigms of modern drug discovery. Recently, multi-component reactions (MCRs) received paramount importance in organic and medicinal chemistry.[1] MCRs leading to interesting heterocyclic scaffolds are particularly useful for the creation of diverse chemical libraries of 'drug-like' molecules for biological screening and the single operation of MCRs leads to a highly efficient synthesis in combinatorial chemistry.[2–4]

The pyridine nucleus is a key constituent, present in a range of bioactive compounds, occurring both synthetically and naturally with wide range of biological applications.[5,6] Among the successful examples as drug candidates possessing pyridine nucleus are streptonigrin, streptonigrone and lavendamycin which are described in the literature as anticancer drugs, and cerivastatin is reported as the HMG-CoA enzyme inhibitor.[7] Substituted pyridines are used as leukotriene B-4 antagonists.[8] In particular 2,2′-pyridines and its derivatives have been invoked as functional modules within the domain of supramolecular chemistry, coordination chemistry and material science.[9] They are employed as chelating ligands in coordination chemistry, building blocks in supramolecular chemistry, as metal-containing polymers, molecular electronics, optoelectronic devices, light-emitting diodes, solar cells and as photo-activated species.[10]

On the other hand 3-substituted indole nucleus is prevalent in numerous natural products and is extremely important in medicinal chemistry.[11,12] Many indole alkaloids are recognized as one of the rapidly growing groups of marine invertebrate metabolites for their broad spectrum of biological properties.[13,14] In addition 3-substituted indole scaffolds are found in a number of biologically active compounds especially with anticancer, anti tumour,[15] hypoglycemic, anti-inflammatory, analgesic and anti-pyretic activities.[16]

Due to the medicinal potential of pyridine and 3-substituted indole derivatives, various methods for the preparation of these compounds have been reported. Marchalin and Kuthan reported the synthesis of 2, 4, 6 triaryl 3-cyanopyridines using condensation of 3-aryl-2-benzylidene-3-oxopropanenitrile, acetyl derivative and ammonium acetate in moderate yields.[17] However these methods suffer from tedious synthetic routes, longer reaction time, drastic reaction conditions, as well as from narrow substrate scope.[9,10,18–21] To the best of our knowledge, there have been no reports for the synthesis of 6-(indol-3-yl)-2,2′-bipyridines. As part of our ongoing research in the development of novel synthetic routes for synthesis of biologically active heterocyclic compounds and use of green chemical techniques in organic synthesis,[22,23] herein, we report a simple and facile one-pot procedure for the synthesis of 6-(indol-3-yl)-2,2′-bipyridine derivatives under neat condition.

Initial studies were carried out with reaction of *p*-tolualdehyde (**1b**), 2-acetyl pyridine (**2**) and 3-(cyanoacetyl)indole (**3**)[24] in the presence of ammonium acetate in various solvents such as DMF, methanol, acetonitrile, water and ethanol under solvent-less

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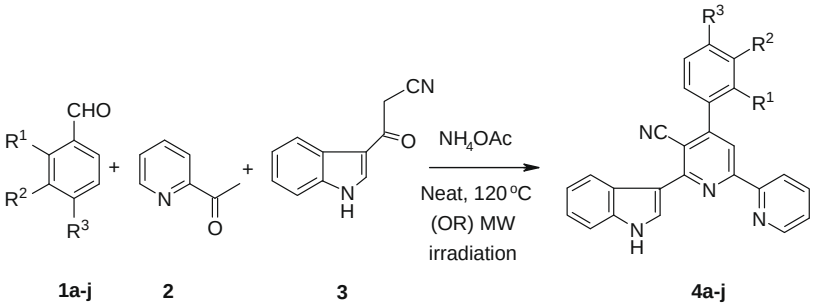


Scheme 1. Synthesis of 6-(indol-3-yl)-2,2′-bipyridine derivatives **4a–j**.

condition at 120 °C for 6 h. Excellent results were obtained under neat condition at 120 °C with high yield in a shorter reaction time. So we followed the reaction that employs, heating a mixture of aldehyde, 2-acetyl pyridine, 3-(cyanoacetyl)indole and ammonium acetate at 120 °C.

The reaction proceeded smoothly with a wide range of functionalized aldehydes, including those containing ether, nitro, halogens and polyaromatic groups (Scheme 1 and Table 1). We extended our investigation to the microwave-activated synthesis of 6-(indol-3-yl)-2,2′-bipyridine derivatives. The yield of the product was good and isolation was similar to that of conventional method. The results are summarized in Table 1.

Based on the above results, a tentative mechanistic interpretation to explain the formation of 6-(indol-3-yl)-2,2′-bipyridine derivatives (Scheme 2) is proposed. Initially, aryl aldehyde **1** reacts with 3-(cyanoacetyl)indole **3** to form the unsaturated ketone **3a**, which in turn adds 2-acetylpyridine (**2**, in its enol form **2′**) to give compound **3b**/**3b′**. The latter reacts with ammonium acetate to form an intermediate **3c**/**3c′**, which by elimination of water gives the Hantzsch 1,4-dihydropyridine **3d**. Under the reaction conditions the latter undergoes ready dehydrogenation to the aromatized pyridine derivative **4**.

The structures of products **4a–j** were confirmed by spectral studies and elemental analysis as exemplified for compound **4h** as follows: The IR spectrum of **4h** showed absorptions at 2217 and 3332 cm^{-1} for CN and the indolic NH, respectively. The latter group (D_2O-exchangable) is also represented as a broad signal at δ 11.84 in the ^1H NMR, which also shows the aryl proton signals in the range δ 7.21–8.71. The signal at δ 103.1 in the ^{13}C NMR confirms the presence of the cyano group, while all aryl C atoms gave rise to signals in the range of δ 112.6–157.8. The mass spectrum displayed the (M^++H^+) peak at *m/z* 451.27.[25] Further the structure of the compound was confirmed by single-crystal X-ray diffraction analysis.[26] (Fig. 1)

Whereas from all aldehydes **1a–j** the pyridylpyridines **4a–j** were obtained directly under the reaction conditions (especially, admission of air), only from 2,4-dichlorobenzaldehyde **1k** the Hantzsch 1,4-dihydropyridine **5** could be isolated (78% after conventional heating, up to 81% after microwave activation) and had to be separately dehydrogenated to **6** (Scheme 3).

The structure of the Hantzsch 1, 4-dihydropyridine (**5**) was investigated with spectral studies, elemental analysis and single-crystal X-ray diffraction[25,27] (Fig. 2).

Urea nitrate (20 mol %) was used for the dehydrogenation of **5** in acetonitrile to give an 86% yield of **6** under microwave irradiation.[28]

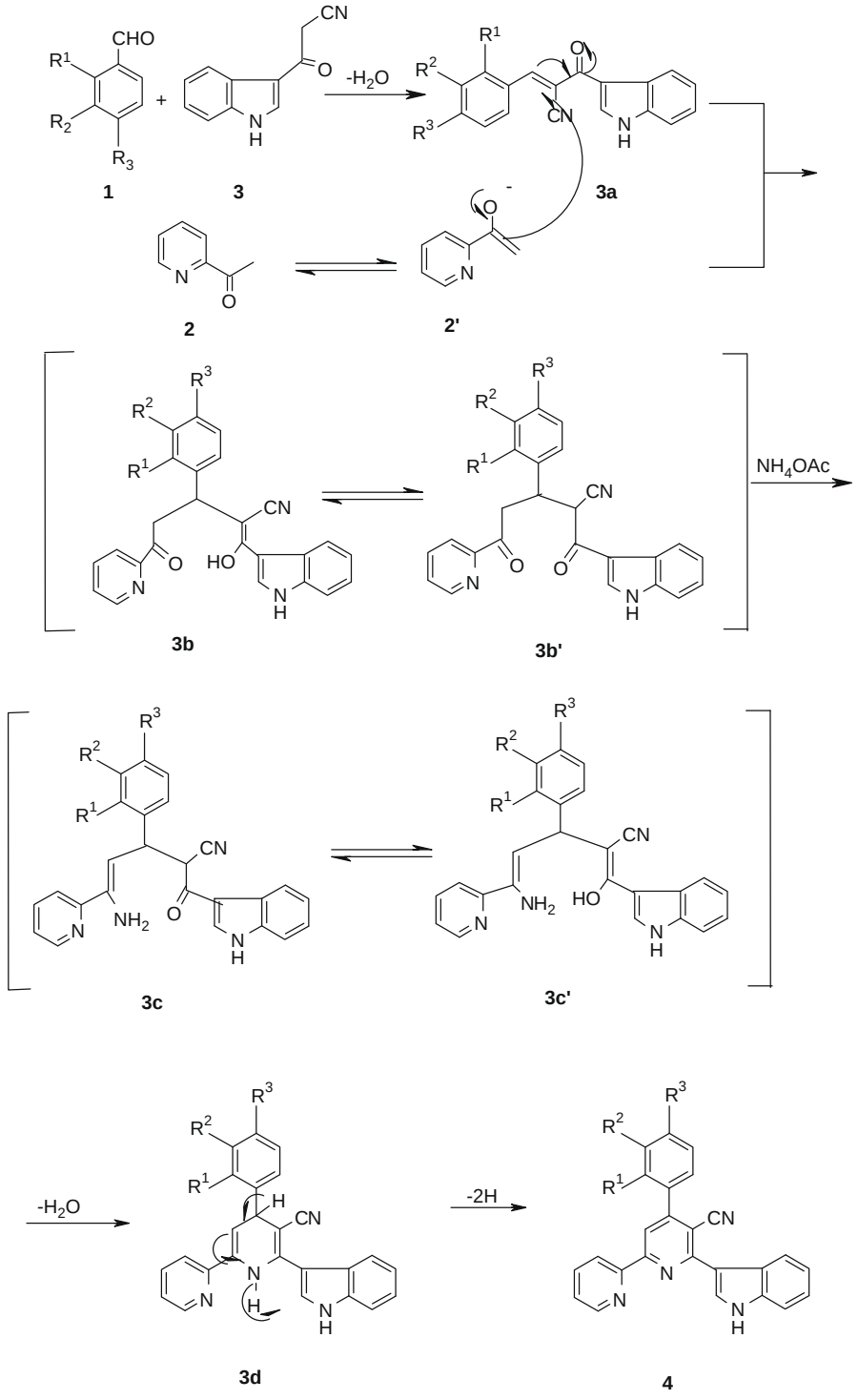
The structure of **6** was supported by the NH and CN stretching frequencies at 3312 and 2239 cm^{-1}, respectively. The aryl protons gave rise to signals in the range δ 7.23–8.72 ppm, and a broad signal at δ 11.89 confirmed the presence of the D_2O-exchangable indolyl NH. The ^{13}C NMR showed the CN carbon at δ. 104.4 and the aryl C-atoms at δ 112.7–157.9 and at *m/z* = 441 the $(M+H)^+$ ion was observed.

We extended our protocol to the synthesis of phenylene-1,4-di[6-(1*H*-indol-3-yl)-2,2′-bipyridine-5,5′-dicarbonitrile] derivatives under optimized conditions. Many bis(bipyridiyl) ligands are capable of forming multi-nuclear complexes. These chelating ligands show particularly high affinities for transition metal ions that frequently stabilize unusually low oxidation state species because of both $d\pi^*$–$p\pi^*$ back-bonding by the cations and their capacity to form ligated anion radicals.[29] Terephthaldialdehyde (0.5 mmol), 3-(cyanoacetyl)indole (1.0 mmol) and 2-acetyl pyridine (1.0 mmol) reacted under optimized conditions to give 68% of product **8**.(Scheme 4)

Table 1
Synthesis of 6-(indol-3-yl)-2,2′-bipyridine derivatives **4a–j**

Entry	Aldehyde (**1**)	R^1	R^2	R^3	Product (**4**)[a]	Conventional heating		Microwave irradiation	
						Time (h)	Yield[b] (%)	Time (h)	Yield[b] (%)
1	**1a**	H	H	H	**4a**	6.5	86	17	88
2	**1b**	H	H	CH_3	**4b**	6.0	87	14	88
3	**1c**	H	CH_3	H	**4c**	6.0	81	15	82
4	**1d**	H	H	OCH_3	**4d**	5.5	'88	14	90
5	**1e**	H	OCH_3	OCH_3	**4e**	5.5	89	13	91
6	**1f**	Phenyl		H	**4f**	6.5	87	18	90
7	**1g**	H	H	Cl	**4g**	6.5	80	16	81
8	**1h**	H	H	Br	**4h**	6.5	79	17	82
9	**1i**	H	H	F	**4i**	6.5	78	16	79
10	**1j**	H	NO_2	H	**4j**	6.5	76	17	77

[a] The products were characterized by NMR, IR and mass and elemental analysis.
[b] Isolated yield.



Scheme 2. A plausible rationale of the reaction.

The structure of 1,4-di[6-(1*H*-indol-3-yl)-2,2′-bipyridine-5,5′-dicarbonitrile] derivative (**8**) was characterized on the basis of elemental analysis and spectral studies. The IR spectrum of compound **8** showed strong absorption band at 2210 cm^{-1} and 3224 cm^{-1} for cyano and indolic NH functional groups. The indolic NH characteristic peak appeared as a broad singlet (D_2O-exchangeable) at δ 11.88 in ^1H NMR spectrum and the aromatic ring protons were resonated in the region of δ 7.23–8.80. A distinguishing peak at δ 102.6 in the ^{13}C NMR spectrum confirmed the presence of cyano carbon and the aromatic carbons were seen in the region of δ 111.8–157.3. The mass spectrum displayed the $[M^+ + H^+]$ peak at *m/z* 667.40.

Encouraged by the above results and due to the unique supramolecular properties of oligopyridine derivatives, we extended the protocol to the synthesis of 6,6′-di(1*H*-indol-3-yl)-4,4′-diaryl-2,2′-bipyridine-5,5′-dicarbonitriles under optimized conditions. 1,6-Diarylhexa-l,5-diene-3,4 dione (cinnamil) is a versatile precursor for the synthesis of oligopyridines. Oligopyridines are

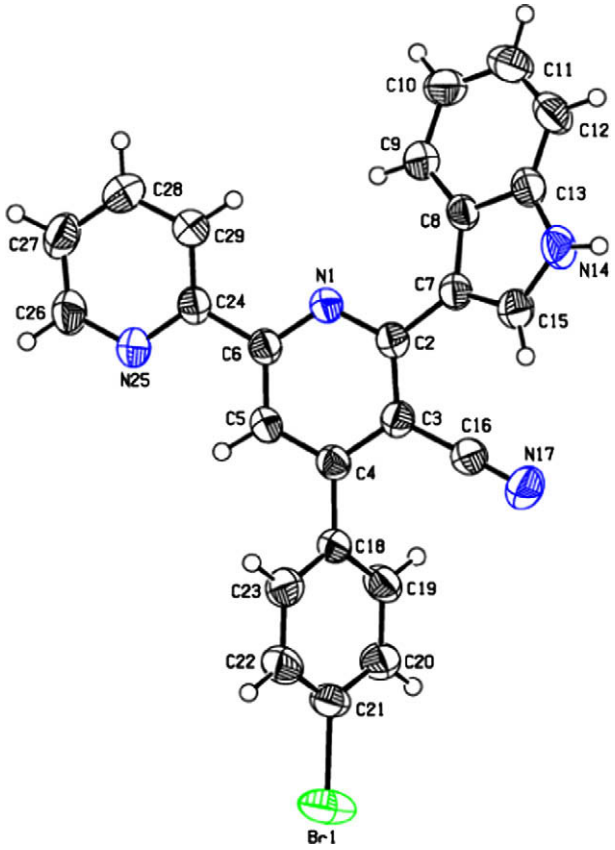


Figure 1. Ortep diagram of compound **4h**.

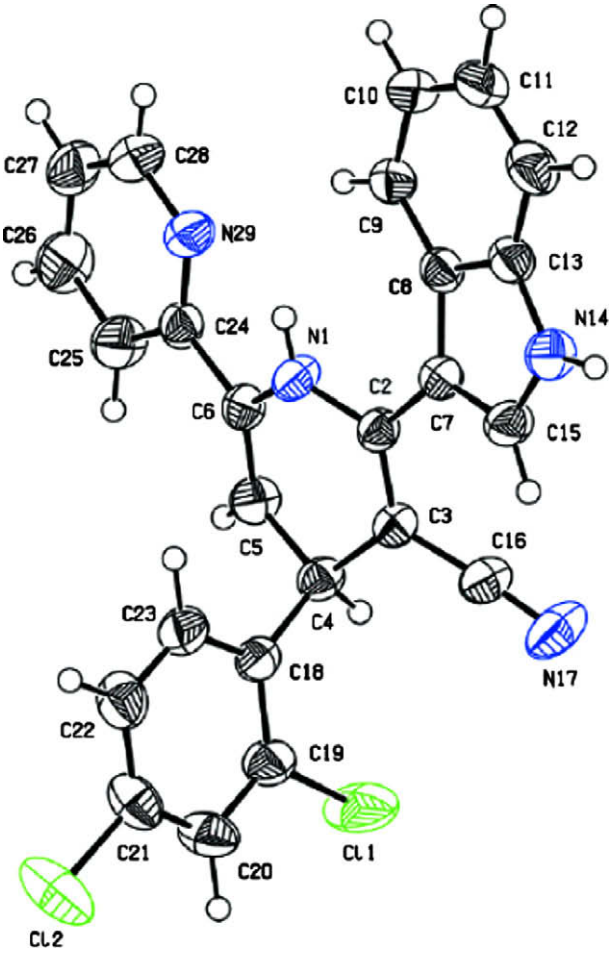
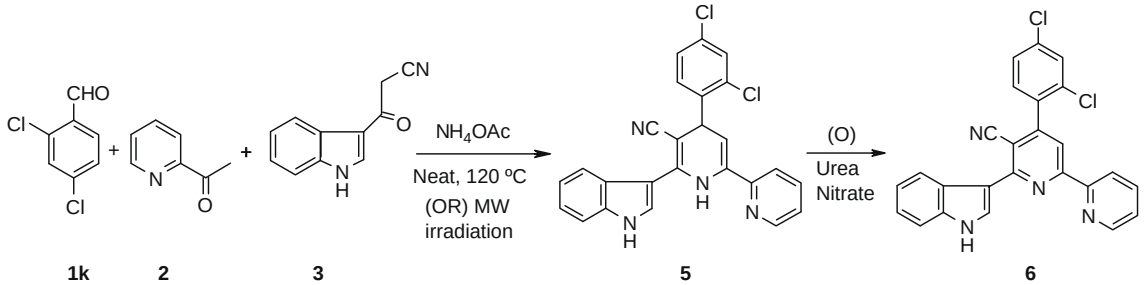


Figure 2. Ortep diagram of compound **5**.

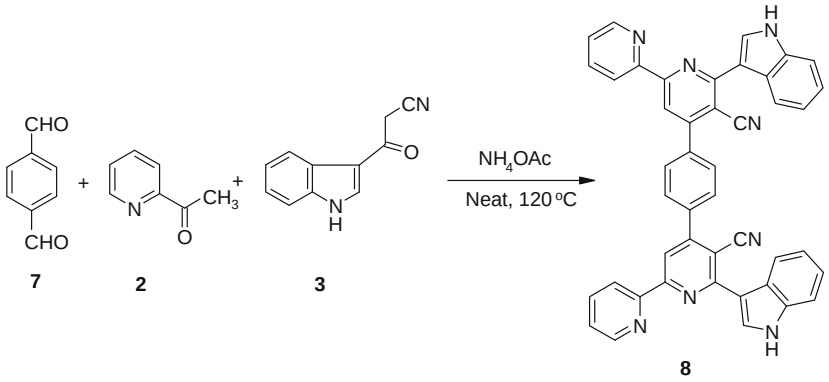
extremely versatile ligands for the assembly of metallosupramolecular systems.[30] 1,6-Diarylhexa-1,5-diene-3,4-diones (cinnamils) **9a–e**,[30] 3-(cyanoacetyl)indole (**3**) and ammonium acetate reacted under optimized conditions to give 2,2′-bi[6-(indol-3-yl)pyridines] **10a–e**. (Scheme 5 and Table 2).

The structures of compounds (**10a–e**) were evaluated based on detailed spectroscopic studies as exemplified for compound **10d** as follows: IR spectrum showed absorption peaks in the region of 2392 and 3416 cm^{-1} indicating the presence of C≡N and NH functional groups, respectively. The ^1H NMR spectrum showed aromatic protons in the region of δ. 7.15–8.44. The NH proton was demonstrated at δ 11.87 (br s, D_2O-exchangeable) and methoxy protons appeared at δ 3.85 as a sharp singlet. In ^{13}C NMR spectra all the aromatic carbons appeared in the region of δ 112.6–161.4 and the distinguishable cyano carbon resonated at δ 103.7. The mass spectra displayed the $[M^+ + H^+]$ peak at *m/z* 649.47.[31]

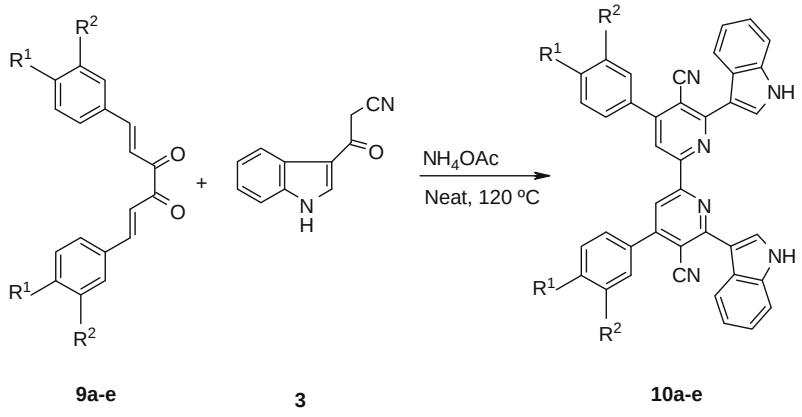
In summary, we have demonstrated a simple, facile and eco-friendly method for the synthesis of 6-(indol-3-yl)-2,2′-bipyridine derivatives through multi-component reaction. The 3-indolyl oligopyridines are versatile ligands in the field of coordination chemistry and supramolecular chemistry. 6-(indol-3-yl)-2,2′-bipyridine derivatives may have enhanced biological activities. Further studies to delineate the scope and limitations of the present methodology are underway.



Scheme 3. Intermediacy of the dihydropyridine derivative **5**.



Scheme 4. Synthesis of phenylene-1,4-di[6-(1*H*-indol-3-yl)-2,2′-bipyridine-5,5′-dicarbonitriles].



Scheme 5. Synthesis of 6,6′-di(1*H*-indol-3-yl)-4,4′-diaryl-2,2′-bipyridine-5,5′-dicarbonitrile derivatives **10a–e**.

Table 2
Synthesis of 6,6′-di(1*H*-indol-3-yl)-4,4′-diaryl-2,2′-bipyridine-5,5′-dicarbonitrile derivatives **10a–e**

Entry	R^1	R^2	Product (**10**)[a]	Time (h)	Yield[b] (%)
1	H	H	**10a**	12.0	65
2	CH_3	H	**10b**	11.0	66
3	H	CH_3	**10c**	12.0	62
4	OCH_3	H	**10d**	10.0	68
5	OCH_3	OCH_3	**10e**	11.0	70

[a] The products were characterized by NMR, IR and mass and elemental analysis.
[b] Isolated yield.

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Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.tetlet.2009.04.121.

References and notes

1. (a) Cui, S. L.; Lin, X. F.; Wang, Y. G. *J. Org. Chem.* **2005**, *70*, 2866; (b) Ramón, D. J.; Miguel, Y. *Angew. Chem., Int. Ed.* **2005**, *44*, 1602; (c) Orru, R. V. A.; de Greef, M. *Synthesis* **2003**, 1471; (d) Weber, L.; Illgen, K.; Almstetter, M. *Synlett* **1999**, 366; (e) Evans, B. E. et al *J. Med. Chem.* **1988**, *31*, 2235.
2. Huang, Y. J.; Yang, F. Y.; Zhu, C. J. *J. Am. Chem. Soc.* **2005**, *127*, 16386.
3. Patchett, A. A.; Nargund, R. P. *Ann. Rep. Med. Chem.* **2000**, *35*, 289.
4. Evdokimov, N. M.; Magedov, I. V.; Kireev, A. S.; Kornienko, A. *Org. Lett.* **2006**, *8*, 899.
5. Ranu, B. C.; Jana, R.; Sowmiah, S. *J. Org. Chem.* **2007**, *72*, 3152.
6. (a) Boger, D. L.; Nakahara, S. *J. Org. Chem.* **1991**, *56*, 880; (b) Boger, D. L.; Kasper, A. M. *J. Am. Chem. Soc.* **1989**, *111*, 1517; (c) Ma, X.; Gang, D. R. *Nat. Prod. Rep.* **2004**, *21*, 752.
7. Bringmann, G.; Reichert, Y.; Kane, V. V. *Tetrahedron* **2004**, *60*, 3539.
8. Zhou, Y.; Kijima, T.; Kuwahara, S.; Watanabe, M.; Izumi, T. *Tetrahedron Lett.* **2008**, *49*, 3757.
9. (a) Cooke, M. W.; Hanan, G. S. *Chem. Soc. Rev.* **2007**, *36*, 1466; (b) Constable, E. C. *Chem. Soc. Rev.* **2007**, *36*, 246; (c) Medlycott, E. A.; Hanan, G. S. *Chem. Soc. Rev.* **2005**, *34*, 133.
10. (a) Lehn, J. M. *Supramolecular Chemistry, Concepts and Perspectives*; VCH: Weinheim, 1995; (b) Kaes, C.; Katz, A.; Hosseini, M. W. *Chem. Rev.* **2000**, *100*, 3553; (c) Gribble, G. W. *J. Chem. Soc., Perkin Trans. 1* **2000**, 1045.
11. Xiong, W. N.; Yang, C. G.; Jiang, B. *Bioorg. Med. Chem.* **2001**, *9*, 1773.
12. Franco, L. H.; Joffe, E. B. K.; Puricelly, L.; Tatian, M.; Seldes, A. M.; Palermo, J. A. *J. Nat. Prod.* **1998**, *61*, 1130.
13. Zhu, S. L.; Ji a, S. J.; Zhao a, K.; Liu a, Y. *Tetrahedron Lett.* **2008**, *49*, 2578.
14. Zhu, S. L.; Ji a, S. J.; Su a, X. M.; Sun a, C.; Liu a, Y. *Tetrahedron Lett.* **2008**, *49*, 1777.
15. Farghaly, A. M.; Habib, N. S.; Khalil, M. A.; El-Sayed, O. A.; Alexandria *J. Pharm. Sci.* **1989**, *3*, 90.
16. (a) Tietze, L. F. *Chem. Rev.* **1996**, *96*, 115; (b) Domling, A. *Chem. Rev.* **2006**, *106*, 17.
17. Marchalin, S.; Kuthan, J. *Czech. Chem. Commun.* **1985**, *50*, 1862.
18. Radwana, M. A. A.; El-Sherbiny, M. *Bioorg. Med. Chem.* **2007**, *15*, 1206.
19. (a) Sun, C.; Jun Ji, S.; Liu, Y. *Tetrahedron Lett.* **2007**, *48*, 8987; (b) Radwan, M. A. A.; Ragab, E. A.; Sabrya, N. M.; El-Shenawyc, S. M. *Bioorg. Med. Chem.* **2007**, *15*, 3832.
20. Abdallah, T. A. *J. Heterocycl. Chem.* **2007**, *44*, 961.
21. Zaki, M. E. A.; Proenc, M. F. *Tetrahedron* **2007**, *63*, 3745.

22. Sridharan, V.; Perumal, P. T.; Avendano, C.; Menendez, J. C. *Tetrahedron* **2007**, *63*, 4407.
23. Thirumurugan, P.; Muralidharan, D.; Perumal, P. T. *Dyes Pigments* **2009**, *81*, 245.
24. Slatt, J.; Romero, I.; Bergman, J. *Synthesis* **2004**, *16*, 2760.
25. *Typical experimental procedure for* **4h** *and* **5a**: **Method I:** A mixture of 3-(cyanoacetyl)indole (1 mmol), 4-bromobenzaldehyde or 2, 4 dichlorobenzaldehyde (1 mmol) and 2-acetyl pyridine (1 mmol) in 5 g of ammonium acetate under neat condition was refluxed at 120 °C for 6–8 h in atmospheric condition. After the completion of the reaction (as monitored by TLC), it was poured into water and extracted with ethyl acetate. The organic layer was dried over sodium sulfate and concentrated under vacuo. The crude product was chromatographed in silica gel with ethyl acetate and petroleum ether mixture. **Method II**: A mixture of 3-(cyanoacetyl)indole (1 mmol), 4-bromoaldehyde or 2,4-dichlorobenzaldehyde (1 mmol) and 2-acetyl pyridine (1 mmol) in 5 g of ammonium acetate in a sealed tube was kept in microwave oven (BPL BMG 800 TS model) irradiated at 150 W at pulse rate 30 s for 16–18 min under neat condition. The product isolation was similar to that of conventional method. Spectral data for compound **4h**: *6-(1H-Indol-3-yl)-4-(4-bromophenyl)-2,2′-bipyridine-5-carbonitrile* (Table 2, entry 8) Pale Yellow solid; mp 298–300 °C; R_f 0.33 (20% AcOEt/petroleum ether); IR (KBr): 1010, 1140, 1212, 1435, 1535, 2217, 3332 cm^{-1}; ^1H NMR (500 MHz, DMSO-d_6): δ 7.21–7.24 (m, 2H, aryl H), 7.52–7.54 (m, 2H, aryl H), 7.67 (d, 2H, J = 8.4 Hz, aryl H), 7.74 (d, 2H, J = 8.4 Hz, aryl H), 8.02 (t, 1H, J = 8.4 Hz, aryl H), 8.21 (s, 1H, aryl H), 8.34–8.37 (m, 2H, aryl H), 8.50 (d, 1H, J = 8.4 Hz, aryl H), 8.71 (d, 1H, J = 4.56 Hz, aryl H), 11.84 (br s, 1H, –N*H*); ^{13}C NMR (125 MHz, DMSO-d_6): 103.1, 112.6, 113.2, 116.5, 119.0, 121.4, 121.7, 122.0, 122.9, 124.0, 125.8, 126.5, 129.3, 131.3, 132.3, 136.4, 136.9, 138.2, 150.1, 154.2, 154.3, 157.7, 157.8; MS (EI): m/z 451.27 [M^++H^+]; Anal. Calcd for $C_{25}H_{15}Br\ N_4$: C, 66.53; H, 3.35; N, 12.41. Found: C, 66.43; H, 3.36; N, 12.46. Spectral data for compound **5:** *4-(2,4-Dichlorophenyl)-6-(1H-indol-3-yl)-1,4-dihydro-2,2′-bipyridine-5-carbonitrile* Yellow solid; mp 212–214 °C; R_f 0.23 (20% AcOEt/petroleum ether); IR (KBr): 1046, 1100, 1432, 1432, 1465, 1561, 1593, 2188, 3385 cm^{-1}; ^1H NMR (500 MHz, DMSO-d_6): δ 5.06 (d, 1H, J = 5.35 Hz, dihydropyridyl aryl H), 5.83 (d, 1H, J = 5.35 Hz, dihydropyridyl aryl H), 7.14 (t, 1H, J = 7.6 Hz, aryl H), 7.19 (t, 1H, J = 7.6 Hz, aryl H), 7.34–7.37 (m, 1H, aryl H), 7.48–7.52 (m, 2H, aryl H), 7.56 (d, 1H, J = 8.4 Hz, aryl H), 7.63 (d, 1H, J = 2.3 Hz), 7.72 (d, 1H, J = 7.6 Hz, aryl H), 7.80–7.83 (m, 1H, aryl H), 7.87 (d, 1H, J = 8.4 Hz, aryl H), 7.95 (d, 1H, J = 3.1 Hz, aryl H), 8.54 (d, 1H, J = 4.6 Hz, aryl H), 8.64 (br s, 1H, N*H*), 11.83 (br s, 1H, –N*H*); ^{13}C NMR (125 MHz, DMSO-d_6)**:** 74.5, 100.6, 107.8, 112.5, 119.2, 119.3, 120.4, 121.6, 122.2, 123.7, 124.6, 127.6, 128.3, 128.9, 132.0, 132.4, 133.5, 136.2, 137.3, 141.6, 146.2, 148.4, 149.4; MS (EI): m/z 443.32 [M^++H^+]; Anal. Calcd for $C_{25}H_{16}Cl_2N_4$: C, 67.73; H, 3.64; N, 12.64. Found: C, 67.89; H, 3.62; N, 12.60.
26. Ramesh, P.; Subbiahpandi, A.; Thirumurugan, P.; Perumal, P. T.; Ponnuswamy, M. N. *Acta Crystallogr., Sect. E* **2009**, *65*, o450.
27. Ramesh, P.; Subbiahpandi, A.; Thirumurugan, P.; Perumal, P. T.; Ponnuswamy, M. N. *Acta Crystallogr., Sect. E* **2008**, *64*, o1891.
28. Anniyappan, M.; Muralidharan, D.; Perumal, P. T. *Tetrahedron* **2002**, *58*, 5069.
29. Kelly, T. R.; Lebedev, R. L. *J. Org. Chem.* **2002**, *67*, 2197.
30. Constable, E. C.; Harverson, P.; Smlth, D. F.; Whall, L. A. *Tetrahedron* **1994**, *50*, 7799.
31. *Experimental procedure for compound* **10d:** A mixture of 3-(cyanoacetyl)indole (2 mmol), 1,6-bis(4-methoxyphenyl)hexa-1,5-diene-3,4-dione (1 mmol) and 5 g of ammonium acetate under neat condition was refluxed at 120 °C for 10 h. After the completion of the reaction (as monitored by TLC), it was poured into water and then filtered, washed with ethanol and then dried. The crude solid obtained was purified further by recrystallisation with DMF and isolated yield was 68%**.** *6,6′-Bis-(1H-indol-3-yl)-4-4′-di-4-methoxyphenyl2,2′bipyridinyl-5,5′dicarbonitrile* (Table 2, entry 4) Yellow solid; mp >350 °C; R_f 0.15 (20% AcOEt/petroleum ether); IR (KBr): 1027, 1251, 1428, 1529, 1609, 2392, 3416 cm^{-1}; ^1H NMR (500 MHz, DMSO-d_6): δ 3.85 (s, 6H, aryl-OCH_3), 7.15–7.24 (m, 8H, aryl H), 7.52 (d, 2H, J = 8.4 Hz, aryl H), 7.79 (d, 4H, J = 8.4 Hz), 8.40–8.44 (m, 6H, aryl H), 11.87 (br s, 2H, –N*H*); ^{13}C NMR (125 MHz, DMSO-d_6): 56.0, 103.7, 112.6, 113.5, 115.0, 117.8, 119.1, 121.1, 121.9, 122.9, 126.7, 129.3, 129.5, 130.6, 137.1, 155.5, 156.5, 158.1, 161.4; MS (EI): m/z 649.47 [M^++H^+]; Anal. Calcd for $C_{42}H_{28}N_6O_2$: C, 77.76; H, 4.35; N, 12.95. Found: C, 77.65; H, 4.36; N, 13.00.