A Facile and Effective Procedure for Synthesis of Polyfunctionalized Bis (imidazolyl) Pyrrole/Imidazolyl Indole from Pyrrole/Indole with Arylglyoxals and *N*-aryl amidines

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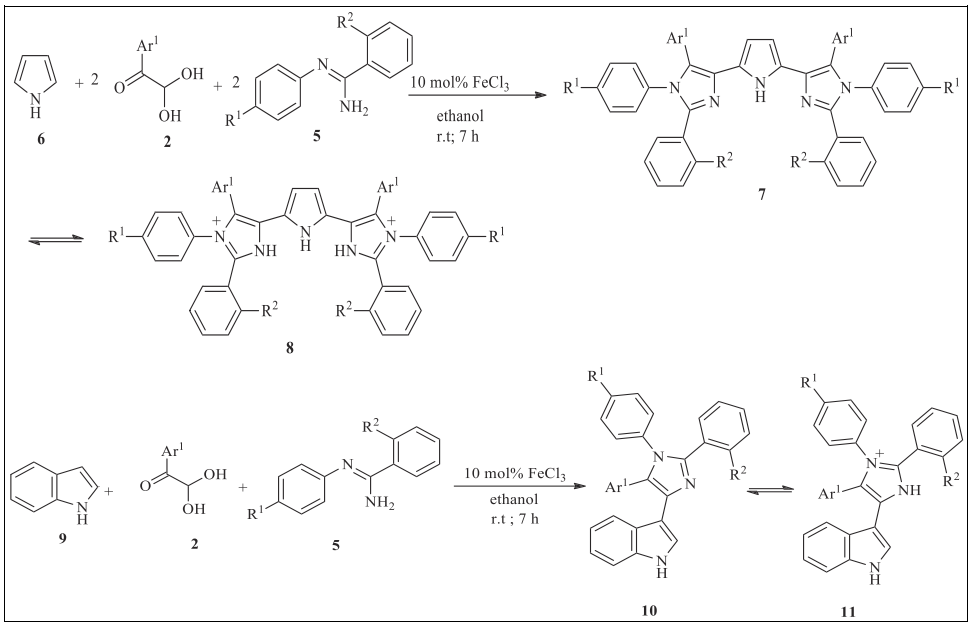

Heterocyclic systems containing bis (imidazolyl) pyrrole or imidazolyl indole moieties were synthesized by heterocyclization of pyrrole or indole with arylglyoxal monohydrates and *N*-aryl amidines in ethanol catalyzed by $FeCl_3$ at room temperature. The paper reports a facile, efficient, and environmentally friendly protocol for the synthesis of new products. Products were isolated by simple filtration, and their structures were established from their spectroscopic data.

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INTRODUCTION

Heterocyclic compounds play an important role in various areas. One of the versatile compounds used in pharmaceuticals is imidazole that is employed to prepare different types of drugs. Imidazoles are a building block of many drugs [1]. Its derivatives have opened up new horizons in clinical medicines. Medicinal properties of imidazole derivatives include anticancer, anticoagulant, antibacterial, anti-inflammatory, antifungal, antiviral, antitubercular, antimalarial, and antidiabetics [2–8]. Heterocyclic compounds have found many applications in remedying different dispositions in clinical medicines [9]. The insertion of imidazole nucleus is an important synthetic plan in drug discovery practices. These are now used as tools in pharmacological research. The valuable therapeutic properties of imidazole-related drugs have encouraged medicinal chemists to synthesize and test a lot of novel molecules [10]. Multicomponent domino reactions serve as a rapid and efficient tool for the synthesis of versatile heterocyclic compounds, especially those containing structural diversity and complexity, by a one-pot operation [11]. A series of pyrrole, imidazole-substituted bis-benzimidazole conjugates were synthesized in an attempt to target double-stranded DNA sequences possessing both adenine-thymine and guanine-cytosine base pairs [12]. The imidazole/pyrrole pair has been subject to considerable studies, including analyses of binding in hundreds of various sequence contexts and crystal structures confirming the existence of a hydrogen bond between the exocyclic amine of guanine and the imidazole nitrogen [13]. With this background in mind and in continuation of our previous works on the development of multicomponent approaches to

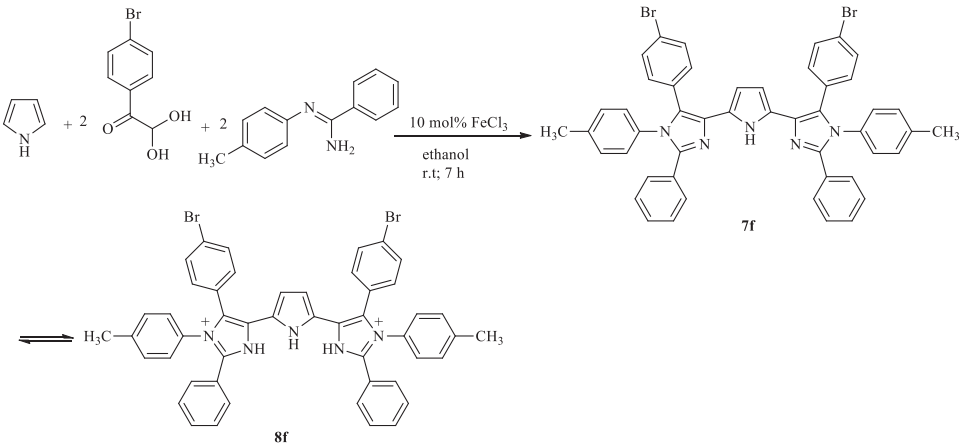
heterocycles [14–16], we report a simple multicomponent reaction between pyrrole or indole with arylglyoxal monohydrates and *N*-aryl amidines in an environmentally favorable moderate (ethanol) under mild reaction conditions for the synthesis of 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole (Scheme 1) or 3-(1*H*-imidazol-4-yl)-1*H*-indole derivatives (Scheme 2), respectively, in high yields.

RESULTS AND DISCUSSION

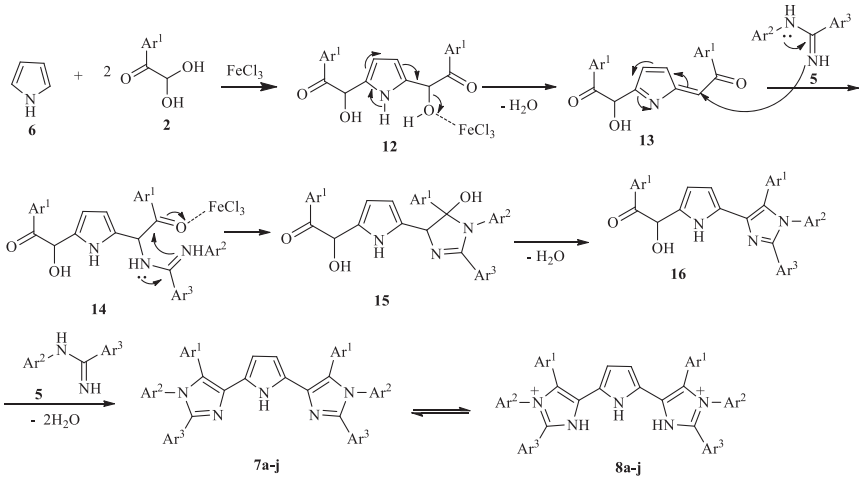
In a typical reaction, pyrrole was first reacted with 4-bromophenylglyoxal in ethanol. After 1 h stirring at room temperature, (*Z*)-*N*'-*p*-tolylbenzamidine was added to the reaction mixture. The reaction course was monitored by thin-layer chromatography (TLC). After 6 h stirring, the starting materials were disappeared on TLC and one pot appeared, which was identified to be 5-(4-bromophenyl)-4-(5-(5-(4-bromophenyl)-2-phenyl-1-*p*-tolyl-1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-2-phenyl-1-*p*-tolyl-1*H*-imidazole **7 f**. Compound **7f** was isolated as a cream solid in 87% yield to offer a highly pure product (Scheme 3).

To find the optimized conditions, the reaction of pyrrole, 4-bromophenylglyoxal, and (*Z*)-*N*'-*p*-tolylbenzamidine in the presence of $FeCl_3$ was selected as the model reaction. The amount of $FeCl_3$ was gradually varied from 1 to 15 mol%. The best yield was attained by carrying out the reaction with 1:2:2 mol ratio of pyrrole:arylglyoxals: *N*-aryl amidines at 25 °C in the presence of 10 mol % $FeCl_3$. We also examined this reaction in the presence of other acids such as $ZnCl_2$, $FeBr_3$, $COCl_2$, $AlCl_3$, HCl, and HOAc. Although other acids afforded the product good yields, the best result was obtained by $FeCl_3$ as a catalyst (Table 1). This reaction was also carried out in the presence of indole instead of pyrrole, and as shown in Scheme 2, the reaction was compatible with indole as with pyrrole, and excellent yields of 3-(1*H*-imidazol-4-

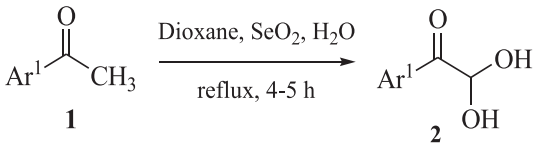
Scheme 1. Reaction between pyrrole, arylglyoxals, and *N*-aryl amidines.



Scheme 2. Reaction between indole, arylglyoxals, and *N*-aryl amidines.



Scheme 3. A typical reaction between pyrrole, 4-bromophenylglyoxal, and (*Z*)-*N*′-*p*-tolylbenzamidine.



Ar^1 =C_6H_5 , 4-FC_6H_4, 4-ClC_6H_4, 4-BrC_6H_4 , 4-$CH_3C_6H_4$, 4-$OCH_3C_6H_4$, 4-$NO_2C_6H_4$

yl)-1*H*-indole derivatives **10a–c** were obtained. We also examined the reactions in acetonitrile as solvent, but the expected 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole derivatives were not obtained in good yields.

Table 1

The effect of different amounts of applied catalysts on the reaction of pyrrole or indole, arylglyoxals, and *N*-aryl amidines.

Entry	Catalyst	Cat (mol%)	Yield (%)
1	$FeCl_3$	1	80
2	$FeCl_3$	5	82
3	$FeCl_3$	10	87
4	$FeCl_3$	15	87
5	HOAc	10	80
6	HCl	10	82
7	$ZnCl_2$	10	75
8	$FeBr_3$	10	80
9	$CoCl_2$	10	70
10	$AlCl_3$	10	65

When benzyl nitrile was used as the nitrile component, a complex mixture of products was obtained, and no product could be isolated from the mixture. So we tried to investigate the reaction of *N*-aryl amidines derived from benzonitrile in the reaction conditions, and the products were obtained in high yields. Then, we examined the influence of different temperatures on a typical reaction for the synthesis of **7f**. To our satisfaction, when the reaction was carried out at room temperature for 7 h, the product showed 87% yield. However, at reflux conditions, the reaction was carried out in 1 h, but due to the formation of by-products, the product exhibited 30% yield. In the absence of any catalyst under the experimental conditions, these reactions take a much longer time to occur.

As shown in Tables 2 and 3, to investigate the generality of the reaction, different arylglyoxals with electron donor and electron withdrawing groups were treated with *N*-aryl amidines, and the related **7a–j** and **10a–c** were obtained in good yields. The products were simply isolated by filtration and washing with diethyl ether. All the reactions were observed to produce high yields (76–87%) compared to other existing procedures. The outcome is listed in Tables 2 and 3. This process has many advantages such as high efficiency, selectivity, easy separation and purification, and mild reaction conditions. They are not only environmentally benign but also economically beneficial because toxic wastes can be minimized or eliminated. All these facts have prompted us to achieve a multicomponent synthesis of 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole or 3-(1*H*-imidazol-4-yl)-1*H*-indole derivatives at room temperature by the mentioned method. All the products shown in Tables 2 and 3 are stable solids, and structure assignments of new products have been established on the basis of elemental analysis and spectral data. Despite symmetry of 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole derivatives, because of high steric hindrance, the hydrodynamic rotation could not take place freely around the single bonds attached to pyrrole ring, but two methyl groups and also two CH of pyrrole ring are

Table 2

The reaction between pyrrole, arylglyoxals, and *N*-aryl amidines.

7	Ar^1	R^1	R^2	Yield[a] (%)
a	-C_6H_5	CH_3	H	86
b	4-FC_6H_4	CH_3	H	78
c	4-FC_6H_4	CH_3	Cl	84
d	4-ClC_6H_4	CH_3	H	84
e	4-ClC_6H_4	CH_3	Cl	76
f	4-BrC_6H_4	CH_3	H	87
g	4-$CH_3C_6H_4$	CH_3	H	77
h	4-$OCH_3C_6H_4$	CH_3	Cl	86
i	4-$NO_2C_6H_4$	CH_3	H	82
j	4-$NO_2C_6H_4$	CH_3	Cl	85

Conditions: EtOH, rt, 7 h.
[a]Isolated yield.

Table 3

The reaction between indole, arylglyoxals, and *N*-aryl amidines.

10	Ar^1	R^1	R^2	Yield[a] (%)
a	4-ClC_6H_4	CH_3	H	88
b	4-$OCH_3C_6H_4$	CH_3	Cl	84
c	4-$NO_2C_6H_4$	CH_3	Cl	89

Conditions: EtOH, rt, 7 h.
[a]Isolated yield.

slightly different. These protons are not equivalent, and spectral evidence confirms this. For example, the ^{1}H-NMR spectrum of **7f** exhibited two singlets at 2.19 and 2.21 ppm for two methyl groups. Two signals were observed at 4.87 and 5.03 ppm for the central pyrrole ring in the form of a single signal and a doublet ($^4J_{HH}$ = 4 Hz), respectively. The last is the result of long-range coupling with the NH proton. This coupling between pyrrole NH proton and hydrogen at its 3-position with a planar zigzag orientation has been well established [17,18]. Because compound **7f** could exist in equilibrium with compound **8f**, three nonequivalent NH protons resonated at 6.10, 6.41, and 6.53 ppm. When the spectrum was prepared after the addition of a few droplets of D_2O to DMSO-d_6 solution of compound **7f**, the signals related to the NH protons were disappeared, and the signal related to CH proton of pyrrole ring was converted to a single signal, showing the spin–spin coupling between CH and NH protons (Fig. 1).

The aromatic protons resonated between 6.84 and 7.56 ppm. The ^{13}C-NMR spectrum of **7f** showed that 14 distinct signals for aromatic carbons are consistent with

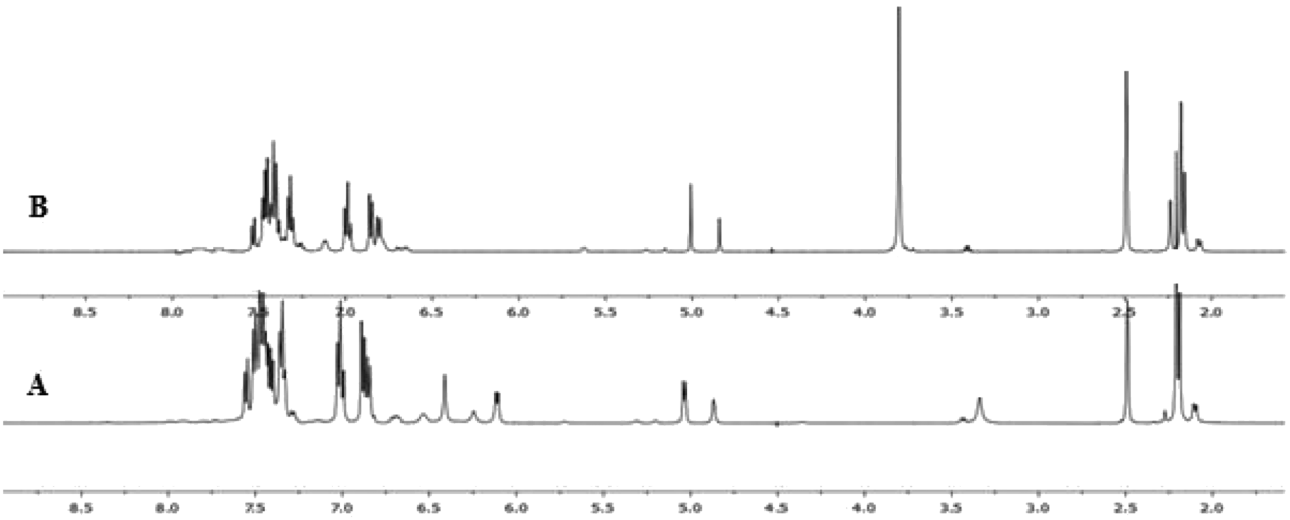
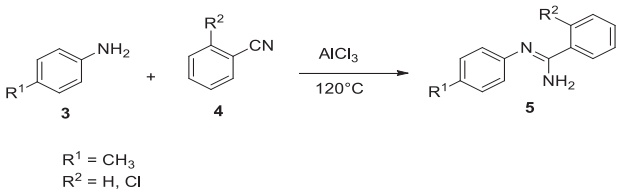
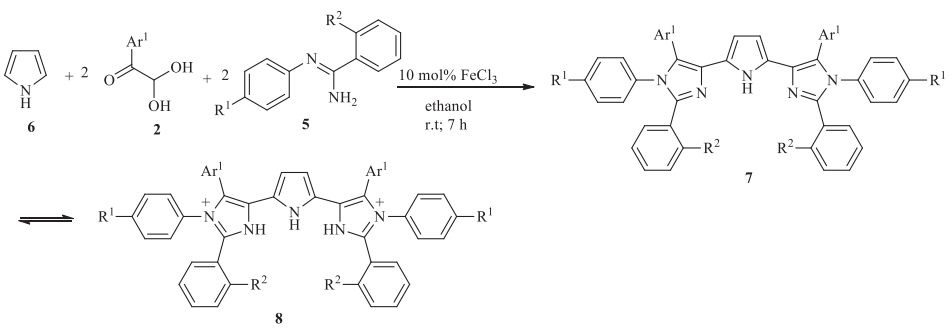


Figure 1. ^{1}H-NMR spectrum of **7f** in DMSO-d_6 (A) and in DMSO-d_6 + D_2O (B).

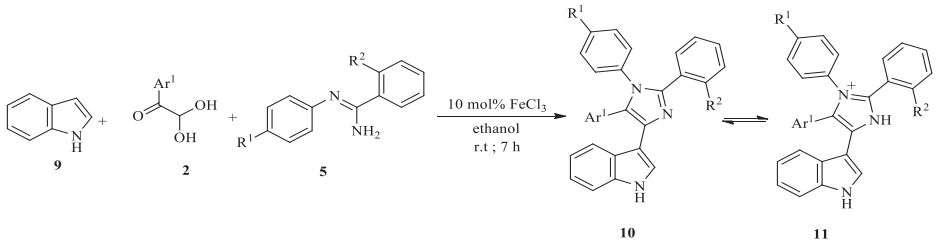
Scheme 4. The suggested mechanism for the formation of 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole derivatives **7a**–**j**.



Scheme 5. Synthesis of arylglyoxal monohydrates.



Scheme 6. Synthesis of *N*-aryl amidines.



9 2 5 10 11

the proposed structure. A downfield signal at 163.45 ppm corresponding to imino carbons present in the molecule. The structure of compound **7f** was also confirmed by its IR spectrum. A broad absorption band at 3452 cm^{-1} was assigned to NH stretching, and an absorption band at 1587 cm^{-1} was assigned to imino groups.

Scheme 4 displays a plausible mechanism for the formation of 4-(5-(1*H*-imidazol-4-yl)-1*H*-pyrrol-2-yl)-1*H*-imidazole derivatives **7a–j** by the reaction between pyrrole, arylglyoxal monohydrates, and *N*-aryl amidines. Pyrrole undergoes electrophilic aromatic substitution with arylglyoxal monohydrates in the presence of $FeCl_3$ to produce 2,5-bis[aroyl (hydroxyl)methyl] pyrrole intermediate **12**. $FeCl_3$ also promoted the formation of intermediate **13** by the elimination of a molecule of water from intermediate **12**. Then, the nucleophilic addition of *N*-aryl amidines **5** to intermediate **13** afforded intermediate **14**. Cyclization yielded **15** followed by the elimination of a molecule of water leading to the formation of bipyrrole intermediate **16** and conceivably similar sequences of reaction steps between bipyrrole **16** and another molecule of *N*-aryl amidines leading to bis (imidazolyl) pyrrole product **7**. Delocalization of *N* lone-pair electrons in substituted imidazole rings promoted the formation of compound **8** from **7**. This mechanism was also applied to the reaction of indole instead of pyrrole with arylglyoxal monohydrates and *N*-aryl amidines to afford monosubstituted indole derivatives.

CONCLUSIONS

In conclusion, we found a simple and efficient method to synthesize of a new class of highly functionalized bis (imidazolyl) pyrrole or imidazolyl indole from pyrrole or indole with arylglyoxals and *N*-aryl amidines in alcoholic media in the presence of $FeCl_3$ as a catalyst. The advantages of this method are the availability of the starting materials, neutral reaction conditions, the use of ethanol as an environmentally green solvent, excellent yields, and simple isolation and purification of the products.

EXPERIMENTAL

Materials and characterization techniques. All the utilized arylglyoxals **2** were synthesized by SeO_2 oxidation of related aryl methyl ketones **1** on the basis of the reported procedure. They were used as their monohydrates (Scheme 5) [19]. The reaction of aryl amines **3** with carbonitriles **4** in the presence of $AlCl_3$ to give amidines **5** was achieved following a literature procedure (Scheme 6) [20]. IR spectra were obtained on a Shimadzu IR-470 spectrometer. The proton and ^{13}C-NMR spectra were recorded on Bruker DRX-400 Avance spectrometer at 400 and 100 MHz, respectively, with Me_4Si as an internal standard in DMSO-d_6. Elemental analysis (C, H, and N) was performed with a Heracus CHN-O-Rapid analyzer. The chemicals used in this work were purchased from Fluka (Buchs, Switzerland) and were used without further purification. All the products were characterized using the NMR and IR spectral and analytical data.

General procedure for synthesis of compounds 7a–j and 10a–c. A mixture of pyrrole (0.5 mmol, for preparation of **7a–j**) or indole (1 mmol, for preparation of **10a–c**) arylglyoxal monohydrates (1 mmol) in ethanol (3 mL) as a green solvent in the presence of 10 mol% of $FeCl_3$ as a catalyst was stirred at room temperature. After 1 h stirring, the amidine derivatives (1 mmol) were added to the reaction mixture. The solution was stirred at ambient temperature for 6 h. After the reaction was completed (indicated by TLC), the resulting precipitate was filtered off and washed with diethyl ether (20 mL) to afford the pure product.

Selected spectral data. ***2,5-Diphenyl-4-(5-(2,5-diphenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-1-p-tolyl-1H-imidazole (7a).*** Yield: 86%; cream powder; m.p.139–140 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3434 (NH), 1589 (C=N). Calcd. for ($C_{48}H_{37}N_5$): C, 84.31; H, 5.45; N, 10.24%. Found: C, 84.16; H, 5.21; N, 10.56%. ^1H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.19 (3H, s, CH_3), 2.21 (3 H, s, CH_3), 4.87 (1H, s, CH of pyrrole), 5.03 (1H, d, $^4J_{HH}$ = 8 Hz, CH of pyrrole), 6.00 (1H, d, $^4J_{HH}$ = 8 Hz, NH), 6.27 (1H, s, NH), 6.50 (1H, s, NH), 6.83-7.52 (27H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.83

(CH_3), 20.89 (CH_3), 95.56, 98.51 (C=C), 124.17, 124.64, 124.93, 125.46, 126.42, 127.28, 128.09, 128.62, 129.16, 129.24, 129.35, 129.63, 129.74, 130.79 (aromatic carbons), 162.57 (C=N).

5-(4-Fluorophenyl)-4-(5-(5-(4-fluorophenyl)-2-phenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-2-phenyl-1-p-tolyl-1H-imidazole (7b). Yield: 78%; white powder; m.p.163–164 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3465 (NH), 1608 (C=N). Calcd. for ($C_{48}H_{35}F_2N_5$): C, 80.09; H, 4.90; N, 9.73%. Found: C, 79.88; H, 4.71; N, 9.55%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.19 (3H, s, CH_3), 2.21 (3 H, s, CH_3), 4.86 (1H, s, CH of pyrrole), 5.02 (1H, d, $^4J_{HH}$ = 8 Hz, CH of pyrrole), 6.07 (1H, d, $^4J_{HH}$ = 4 Hz, NH), 6.35 (1H, s, NH), 6.52 (1H, s, NH), 6.84–7.54 (26H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.82 (CH_3), 20.87 (CH_3), 95.20, 98.20 (C=C), 124.87, 125.01, 127.65, 128.51, 128.59, 129.17, 129.35, 129.63, 130.04, 130.63, 134.30, 138.79, 139.13, 142.26 (aromatic carbons), 162.71 (C=N).

2-(2-Chlorophenyl)-4-(5-(2-(2-chlorophenyl)-5-(4-fluorophenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-5-(4-fluorophenyl)-1-p-tolyl-1H-imidazole (7c). Yield: 84%; cream powder; m.p.148–150 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3439 (NH), 1604 (C=N). Calcd. for ($C_{48}H_{33}Cl_2F_2N_5$): C, 73.10; H, 4.22; N, 8.88%. Found: C, 73.35; H, 4.36; N, 8.65%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.15 (3H, s, CH_3), 2.16 (3 H, s, CH_3), 5.11 (1H, s, CH of pyrrole), 5.24 (1H, d, $^4J_{HH}$ = 8 Hz, CH of pyrrole), 6.06 (1H, d, $^4J_{HH}$ = 8 Hz, NH), 6.43 (1H, s, NH), 6.48 (1H, s, NH), 6.76–7.64 (24H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.76 (CH_3), 20.83 (CH_3), 94.04, 98.65 (C=C), 113.84, 114.01, 115.27, 124.30, 124.92, 127.82, 129.46, 129.50, 130.02, 131.53, 132.12, 134.35, 134.48, 137.03, 138.80, 142.17 (aromatic carbons), 160.44 (C=N).

5-(4-Chlorophenyl)-4-(5-(5-(4-chlorophenyl)-2-phenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-2-phenyl-1-p-tolyl-1H-imidazole (7d). Yield: 84%; cream powder; m.p.168–169 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3450 (NH), 1587 (C=N). Calcd. for ($C_{48}H_{35}Cl_2N_5$): C, 76.59; H, 4.69; N, 9.30%. Found: C, 76.38; H, 4.78; N, 9.45%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.19 (3H, s, CH_3), 2.21 (3 H, s, CH_3), 4.87 (1H, s, CH of pyrrole), 5.03 (1H, d, $^4J_{HH}$ = 4 Hz, CH of pyrrole), 6.10 (1H, d, $^4J_{HH}$ = 4 Hz, NH), 6.41 (1H, s, NH), 6.53 (1H, s, NH), 6.84–7.51 (26H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.84 (CH_3), 20.88 (CH_3), 95.85, 98.20 (C=C), 125.00, 127.26, 127.53, 128.59, 129.16, 129.34, 129.65, 129.74, 129.97, 130.68, 131.97, 134.34, 139.08, 141.76 (aromatic carbons), 162.84 (C=N).

2-(2-Chlorophenyl)-5-(4-chlorophenyl)-4-(5-(2-(2-chlorophenyl)-5-(4-chlorophenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-1-p-tolyl-1H-imidazole (7e). Yield: 76%; cream powder; m.p.148–149 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3440 (NH), 1606 (C=N). Calcd. for ($C_{48}H_{33}Cl_4N_5$): C, 70.17; H, 4.05; N, 8.52%. Found: C, 69.86; H, 4.36; N, 8.76%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.15 (3H, s, CH_3), 2.16 (3 H, s, CH_3), 5.11 (1H, s, CH of pyrrole), 5.24 (1H, d, $^4J_{HH}$ = 8 Hz, CH of pyrrole), 6.11 (1H, bs, NH), 6.31 (1H, s, NH), 6.47 (1H, s, NH), 6.77–7.61 (24H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.78 (CH_3), 20.85 (CH_3), 94.04, 98.59 (C=C), 124.42, 124.96, 127.29, 127.69, 128.50, 129.01, 129.50, 129.95, 130.07, 131.53, 131.57, 131.88, 132.09, 134.58, 136.91, 141.61 (aromatic carbons), 161.09 (C=N).

5-(4-Bromophenyl)-4-(5-(5-(4-bromophenyl)-2-phenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-2-phenyl-1-p-tolyl-1H-imidazole (7f). Yield: 87%; cream powder; m.p.168–169 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3452 (NH), 1587 (C=N). Calcd. for ($C_{48}H_{35}Br_2N_5$): C, 68.50; H, 4.19; N, 8.32%. Found: C, 68.39; H, 4.32; N, 8.45%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.19 (3H, s, CH_3), 2.21 (3 H, s, CH_3), 4.87 (1H, s, CH of pyrrole), 5.03 (1H, d, $^4J_{HH}$ = 4 Hz, CH of pyrrole), 6.10 (1H, d, $^4J_{HH}$ = 8 Hz, NH), 6.41 (1H, s, NH), 6.53 (1H, s, NH), 6.84–7.56 (26H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.77 (CH_3), 20.82 (CH_3), 87.89, 98.12 (C=C), 125.09, 125.26, 127.88, 128.55, 129.37, 129.70, 130.29, 130.45, 131.54, 131.78, 132.05, 134.78, 138.70, 145.19 (aromatic carbons), 163.45 (C=N).

2-Phenyl-4-(5-(2-phenyl-1,5-dip-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-1,5-dip-tolyl-1H-imidazole (7g). Yield: 77%; brown powder; m.p.164–165 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3446 (NH), 1588 (C=N). Calcd. for ($C_{50}H_{41}N_5$): C, 84.36; H, 5.81; N, 9.84%. Found: C, 84.13; H, 5.63; N, 9.96%. ^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 2.18 (3H, s, CH_3), 2.20 (3H, s, CH_3), 2.27 (3H, s, CH_3), 2.29 (3H, s, CH_3), 4.83 (1H, s, CH of pyrrole), 5.01 (1H, d, $^4J_{HH}$ = 4 Hz, CH of pyrrole), 6.05 (1H, s, NH), 6.17 (1H, s, NH), 6.46 (1H, s, NH), 6.77–7.51 (26H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.37 (CH_3), 20.62 (CH_3), 95.52, 98.37 (C=C), 124.22, 124.76, 125.31, 128.14, 128.70, 129.01, 129.87, 130.67, 130.99, 132.94, 134.69, 136.66 (aromatic carbons), 165.88 (C=N).

2-(2-Chlorophenyl)-4-(5-(2-(2-chlorophenyl)-5-(4-methoxyphenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-5-(4-methoxyphenyl)-1-p-tolyl-1H-imidazole (7h). Yield: 86%; white powder; m.p.131–132 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3442 (NH), 1609 (C=N). Calcd. for ($C_{50}H_{39}Cl_2N_5O_2$): C, 73.89; H, 4.84; N, 8.62%. Found: C, 73.77; H, 4.66; N, 8.86%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.15 (3H, s, CH_3), 2.16 (3 H, s, CH_3), 3.74 (6H, s, $2OCH_3$), 5.07 (1H, s, CH of pyrrole), 5.21 (1H, d, $^4J_{HH}$ = 4 Hz, CH of pyrrole), 5.89 (1H, d, $^4J_{HH}$ = 4 Hz, NH), 6.22 (1H, s, NH), 6.49 (1H, s, NH), 6.79–7.55 (24H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.75 (CH_3), 20.82 (CH_3), 94.98, 98.37 (C=C), 112.71, 113.82, 115.07, 123.96, 124.72, 126.90, 127.45, 127.62, 128.99, 129.20, 129.44, 129.49, 129.58, 130.09, 131.55, 131.67, 131.94, 132.17 (aromatic carbons), 160.21 (C=N).

5-(4-Nitrophenyl)-4-(5-(5-(4-nitrophenyl)-2-phenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-2-phenyl-1-p-tolyl-1H-imidazole (7i). Yield: 82%; brown powder; m.p.168–169 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3455 (NH), 1591 (C=N). Calcd. for ($C_{48}H_{35}N_7O_4$): C, 74.50; H, 4.56; N, 12.67%. Found: C, 74.36; H, 4.24; N, 12.85%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): 2.20 (3H, s, CH_3), δ = 2.22 (3H, s, CH_3), 4.92 (1H, s, CH of pyrrole), 5.10 (1H, s, CH of pyrrole), 6.28 (1H, s, NH), 6.47 (1H, s, NH), 6.64 (1H, s, NH), 7.36–8.25 (26H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.91 (CH_3), 95.93, 98.28 (C=C), 122.55, 123.94, 125.16, 125.20, 125.40, 128.54, 128.59, 129.34, 129.40, 129.72, 130.89, 131.37, 134.62, 150.54 (aromatic carbons), 163.38 (C=N).

2-(2-Chlorophenyl)-4-(5-(2-(2-chlorophenyl)-5-(4-nitrophenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-pyrrol-2-yl)-5-(4-nitrophenyl)-1-p-tolyl-1H-imidazole (7j). Yield: 85%; brown powder; m.p.165–166 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3461 (NH), 1607 (C=N). Calcd. for ($C_{48}H_{33}Cl_2N_7O_4$): C, 68.41; H, 3.95; N, 11.63%. Found: C, 68.61; H, 3.73; N, 11.75%. ^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 2.16 (3H, s, CH_3), 2.17 (3H, s, CH_3), 5.16 (1H, s, CH of pyrrole), 5.31 (1H, s, CH of pyrrole), 6.28 (1H, s, NH), 6.70 (1H, s, NH), 6.79 (1H, s, NH), 6.86–8.28 (24H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.80 (CH_3), 20.85 (CH_3), 94.10, 98.68 (C=C), 122.57, 123.87, 124.79, 125.13, 127.15, 127.52, 129.09, 129.34, 129.50, 129.54, 130.05, 131.53, 131.74, 132.07, 134.80, 150.48 (aromatic carbons), 161.29 (C=N).

3-(5-(4-Chlorophenyl)-2-phenyl-1-p-tolyl-1H-imidazol-4-yl)-1H-indole (10a). Yield: 88%; cream powder; m.p.165–168 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3440 (NH), 1606 (C=N). Calcd. for ($C_{30}H_{22}ClN_3$): C, 78.34; H, 4.82; N, 9.14%. Found: C, 78.49; H, 4.73; N, 9.29%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.16 (3H, s, CH_3), 5.11, 5.26 (2H, s, 2NH), 6.10–7.62 (18H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.86 (CH_3), 94.04, 98.65 (C=C), 124.40, 124.97, 127.29, 127.47, 127.70, 128.51, 129.03, 129.51, 129.96, 130.02, 130.08, 131.54, 131.73, 131.95, 132.12, 134.43, 134.55, 136.98, 141.68, 144.89 (aromatic carbons), 160.80 (C=N).

3-(2-(2-Chlorophenyl)-5-(4-methoxyphenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-indole (10b). Yield: 84%; white powder; m.p.180–182 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3409 (NH), 1740 (C=N). Calcd. for ($C_{31}H_{24}ClN_3O$): C, 75.99; H, 4.94; N, 8.58%. Found: C, 76.12; H, 4.58; N, 8.72%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.28 (3H, s, CH_3), 3.74 (3H, s, OCH_3), 6.00, 6.58 (2H, s, 2NH), 6.80–7.69 (17H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.82 (CH_3), 115.34, 115.51 (C=C), 122.12, 122.83, 127.88, 128.64, 128.76, 128.80, 129.00, 129.16, 129.35, 129.63, 129.81, 130.15, 130.32, 131.64, 132.73, 133.06 (aromatic carbons), 168.09 (C=N).

3-(2-(2-Chlorophenyl)-5-(4-nitrophenyl)-1-p-tolyl-1H-imidazol-4-yl)-1H-indole (10c). Yield: 88%; cream powder; m.p.165–168 °C. IR (KBr) ($\bar{\upsilon}_{max}$, cm^{-1}): 3458 (NH), 1607 (C=N). Calcd. for ($C_{30}H_{21}ClN_4O_2$): C, 71.36; H, 4.19; N, 11.10%. Found: C, 71.56; H, 3.97; N, 11.32%. ^{1}H-NMR (DMSO-d_6, 400 MH_Z): δ = 2.15 (3H, s, CH_3), 5.31, 6.29 (2H, s, 2NH), 6.78–8.26 (17H, m, aromatic hydrogens), ^{13}C-NMR (DMSO-d_6, 100 MH_Z): δ = 20.82 (CH_3), 94.13, 98.68 (C=C), 122.57, 124.36, 125.15, 127.15, 127.54, 127.67, 129.29, 129.34, 129.48, 129.55, 129.87, 130.05, 131.54, 131.74, 132.06, 134.82 (aromatic carbons), 161.15 (C=N).

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