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Simple Synthesis of Substituted Pyrroles†

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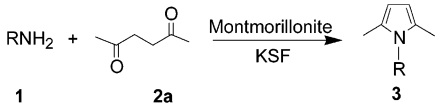
Abstract: Simple synthesis of substituted pyrroles using iodine-catalyzed and montmorillonite KSF-clay-induced modified Paal−Knorr methods has been accomplished with excellent yields. N-Substituted carbazole has also been prepared by following this method. If one of the reactants is a liquid, the reaction proceeds exceedingly well without a solvent. This method gives pyrroles with less nucleophilic multicyclic aromatic amines at room temperature.

Pyrroles are an important class of heterocyclic compounds having different biological activities.[1] Therefore, many methods for the synthesis of substituted pyrroles have been described in the literature.[2] Recently, conjugate addition reactions have been used for the synthesis of polysubstituted pyrroles.[3] These compounds can also be prepared from transition-metal intermediates,[4] reductive couplings,[5] aza-Wittig reactions,[6] and other multistep operations.[7] Despite these new developments, the Paal−Knorr[8] reaction remains one of the most attractive methods for the synthesis of pyrroles. A clay-mediated[9] organic reaction and microwave irradiation method[10] have been used for the construction of pyrroles under Paal−Knorr conditions. These techniques clearly extend the scope of this reaction, but success with less nucleophilic aromatic amines has not been reported. In addition to high-power microwave irradiation, a considerable quantity of acid is always necessary for a Paal−Knorr reaction. Therefore, mild reaction conditions that can overcome some of the shortcomings of previous methods are necessary. In this paper, we describe two simple methods of synthesis of substituted pyrroles by either iodine-catalyzed and montmorillonite KSF clay-induced modified Paal−Knorr reaction. To our knowledge, no other synthetic methods are as simple.

SCHEME 1



We[11] performed a structure−activity relationship study of various polyaromatic derivatives easily prepared from their corresponding amines in a projected route toward the development of novel anticancer agents. It was reported that modification of the heterocyclic ring is crucial in determining the biological activity of these derivatives.[11a] Based on their biological activities, we became interested in the synthesis of pyrroles bound to the polyaromatic amines of different structures. Because the Paal−Knorr method requires Lewis acid as a catalyst, we envision applying our work on iodine-catalyzed[12] and clay-induced[13] organic transformations to facile synthesis of pyrroles under very mild conditions as an alternative.

Recently, clay-mediated facile synthesis of pyrroles following the Paal−Knorr method was demonstrated.[9] Use of silica gel and alumina as the other solids in this reaction was investigated. The reaction did not proceed to completion, and only an insignificant amount of the starting material was consumed. However, the use of montmorillonite KSF under identical conditions resulted in a cleaner reaction. The success of this experiment has strengthened the importance of the nature of the solid support. Furthermore, it does not require a strong acid and alkali, extraction, a heating device, a stirrer, or many of the standard glass apparatuses.

Several amines **1** including monocyclic, bicyclic, tricyclic, tetracyclic aromatic, aliphatic, heterocyclic, and benzylic amines were used for this study. The other starting material, 2, 5-hexandione **2a**, was commercially available (Scheme 1). The reaction was carried out by mixing the clay with a solution of the amine and the ketone in dichloromethane and evaporating the solvent under reduced pressure. The resulting mass was then kept at room temperature for the specified time as indicated in Table 1. The yields of the product **3** are also shown in Table 1. The less basic aromatic amines required a longer reaction time for generation of the products, although the yields were comparable with those using the more basic amino compounds.

Having an attractive route for the synthesis of pyrroles, synthesis of a carbazole in which pyrrole constitutes the central ring was attempted (Scheme 2). The starting 1,4-

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(1) For some biologically active pyrroles, see: (a) Lainton, J. A. H.; Hoffman, J. W.; Martin, B. R.; Compton, D. R. *Tetrahedron Lett*. **1995**, *36*, 1401. (b) De Leon, C. Y.; Ganem, B. *Tetrahedron* **1997**, *53*, 7731.

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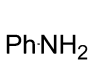
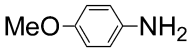
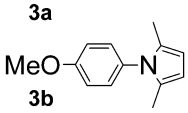
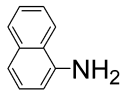
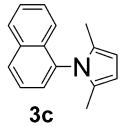
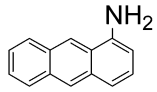
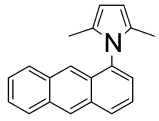
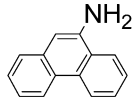
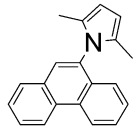
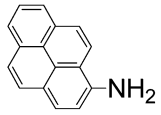
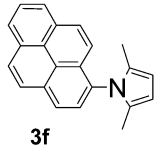
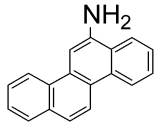
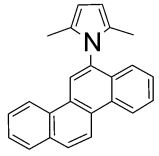
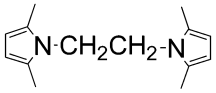
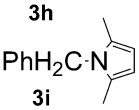
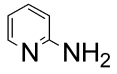
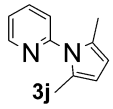
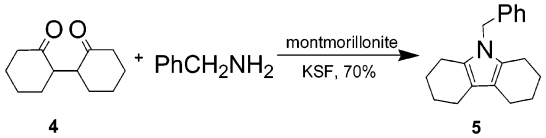
TABLE 1. Monmorillonite KSF-Mediated Synthesis of Pyrrole 3

Entry	Amine (**1**)	Product	Time (h)	Yield (%)
1		 **3a**	10	96
2		 **3b**	15	81
3		 **3c**	11	83
4		 **3d**	19	98
5		 **3e**	18	94
6		 **3f**	20	88
7		 **3g**	22	85
8	$NH_2(CH_2)_2NH_2$	 **3h**	10	85
9	$PhCH_2NH_2$	 **3i**	10	95
10		 **3j**	25	70

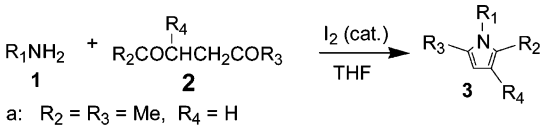
SCHEME 2



4 **5**

diketone **4** was prepared in a ferric chloride-mediated oxidative coupling reaction of cyclohexanone enolate.[14]

SCHEME 3



a: $R_2 = R_3 = Me$, $R_4 = H$
b: $R_2 = Me$, $R_3 = Ph$, $R_4 = H$
c: $R_2 = R_3 = R_4 = Ph$

Condensation of the diketone **4** with benzylamine as described above afforded the tricyclic carbazole **5** in excellent yield. N-Substituted carbazole by clay-mediated synthesis is noteworthy because of the considerable synthetic attention they have attracted as potential carcinogens and several other interesting biological activities.[15] Synthesis of N-unsubstituted carbazoles was demonstrated previously using Fisher's or Bucherer's method.[6] However, the reaction conditions are not mild, and an alkylation step is necessary to obtain an N-substituted product.

As a result of our continuous effort to make the synthetic chemistry simple and practical,[16] we discovered that synthesis of substituted pyrroles can also be achieved in iodine-catalyzed reactions.[17] Our work in this field has culminated in a very simple iodine-catalyzed preparation of pyrroles in a relatively short time with outstanding yield (Scheme 3). This reaction is even more simple than the clay-mediated reaction described below. The starting materials (amines and ketones) are mixed with iodine in the presence of THF or dichloromethane, and the solution is kept at room temperature for a specified time. If one of the reactants is a liquid, the reaction can proceed without a solvent. Even ordinary-grade solvents and reagents can be used with equal success. However, if the reaction mixture is a very thick slurry, the addition of a small amount of solvent (1 g of the substrate/1 mL of the solvent) may be necessary for a complete reaction.

Aliphatic, heterocyclic, and benzylic amines were used for this study, the results of which are shown in Table 2. The less basic aromatic amines required a longer reaction time, although the yields were comparable with those using the more basic amino compounds.

It is interesting that this method of pyrrole formation proceeds exceedingly well with multicyclic aromatic systems (Table 2, entries 3−7) and heterocyclic amine (Table 2, entry 10) without the need for Lewis acid or other strong acids.

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(16) We have been actively engaged in devising synthetic methods that are practical or ecologically friendly. For example, see: (a) Banik, B. K.; Suhendra, M.; Banik, I.; Becker, F. F. *Synth. Commun*. **2000**, *30*, 3745. (b) Banik, B. K.; Banik, I.; Hackfeld, L.; Becker, F. F. *Heterocycles* **2001**, *56*, 467. (c) Banik, B. K.; Hackfeld, L.; Becker, F. F. *Synth. Commun*. **2001**, *31*, 129. (d) Samajdar, S.; Becker, F. F.; Banik, B. K. *Synth. Commun*. **2001**, *31*, 2691. (e) Mukhopadhyay, C.; Becker, F. F.; Banik, B. K. *Synth. Commun*. **2001**, *31*, 2399. (f) Dasgupta, S. K.; Banik, B. K. *Tetrahedron Lett*. **2002**, *43*, 9445. (g) Banik, B. K.; Samajdar, S.; Banik, I. *Tetrahedron Lett*. **2003**, *44*, 1699. (h) Srivastava, N.; Banik, B. K. *J. Org. Chem*. **2003**. *68*, 2109. (i) Banik, B. K.; Banik, I.; Becker, F. F. *Org. Synth*. **2003**, in press.

(17) One of the authors, B.K.B., was involved in the study of iodine-catalyzed reactions. For examples, see: (a) Banik, B. K.; Manhas, M. S.; Bose, A. K. *J. Org. Chem*. **1994**, *59*, 4714. (b) Banik, B. K.; Manhas, M. S.; Bose, A. K. *Tetrahedron Lett*. **1997**, *38*, 5077. (c) Banik, B. K.; Zegrocka, O., Manhas, M. S.; Bose, A. K. *Heterocycles* **1997**, *27*, 173.

TABLE 2. Iodine-Catalyzed Synthesis of Pyrrole 3

entry	R_1	R_2	R_3	R_4	yield of product (%)	time (h)
1	phenyl (**3a**)	Me	Me	H	90	0.5
2	4-anisyl (**3b**)	Me	Me	H	84	1.5
3	1-naphthalenyl (**3c**)	Me	Me	H	85	1
4	1-anthracenyl (**3d**)	Me	Me	H	88	1
5	9-phenanthrenyl (**3e**)	Me	Me	H	91	1
6	1-pyrenyl (**3f**)	Me	Me	H	87	1.5
7	6-chrysenyl (**3g**)	Me	Me	H	80	1.5
8	1-ethyl-2′,5′-dimethyl (**3h**)	Me	Me	H	90	0.5
9	benzyl (**3i**)	Me	Me	H	92	0.5
10	2-pyridyl (**3j**)	Me	Me	H	78	1
11	phenyl (**3k**)	Me	Ph	H	91	7
12	benzyl (**3l**)	Me	Ph	H	89	9
13	1-butyl (**3m**)	Me	Ph	H	93	8
14	cyclopentyl (**3n**)	Me	Ph	H	76	10
15	phenyl (**3o**)	Ph	Ph	Ph	15	20

This indicates the capability of iodine as an activator, although the conditions of the reactions are mild in comparison with those in other reported methods. In addition, all of the iodine-catalyzed reactions were successful at room temperature. Previously, even with simple aniline derivatives, a high temperature and/or microwave irradiation were required.

To improve the scope of this iodine-catalyzed method of pyrrole formation, substituted diketones **2b** and **2c** were used as the substrates. Clean formation of pyrroles under identical conditions as described above was observed with **2b**. As a result, several 1, 2, 5-trisubstituted pyrroles were accessible (entries 11−14).

However, a clear difference in the rate of the reaction as well as the yield of the product was apparent when **2c** was used. The reaction between **1** and **2c** was remarkably slow, and the yield of the product from this reaction was low (entry 15). An improvement in yield (up to 30%) and the rate of the reaction was achieved by using a higher proportion of iodine (30 mol %), but the reaction still did not proceed to completion. The three aromatic groups present in **2c** spoiled the success of the reaction considerably, although a single aromatic group as in **2b** seems to impose little hindrance.

Reactions between **1** and **2** do not proceed without iodine. The presence of a small amount of iodine (5−10 mol %) is essential for the success of the reaction. Therefore, the involvement of hydroiodic acid is speculated, as iodine can liberate hydroiodic acid in media via reaction with an organic solvent and substrate. This was experimentally verified in a reaction of amine and the diketone in the presence of a small amount of hydroiodic acid (1 equiv). Although such reaction proceeds in the presence of hydroiodic acid, the isolated yields of the products are not comparable with those of iodine-catalyzed reactions. Since the product is basic, neutralization by alkali is absolutely necessary when the catalyzing agent is hydroiodic acid, whereas no neutralization is required in the iodine-catalyzed reactions. This may account for loss of the product during extraction in hydroiodic acid-mediated reaction. On the other hand, the use of molecular iodine as the catalyst seems to be very convenient from a practical point of view.

The present iodine-catalyzed and clay-induced methods are much superior to Lewis acid-mediated synthesis of pyrroles in terms of product yield. In addition, no extra energy source, such as microwave irradiation or ultrasound, is needed for the success of the reactions. Most importantly, these methods have been shown to be versatile pyrrole synthesis procedures, even with less nucleophilic multicyclic aromatic amines. We believe that our methods are general for most kinds of primary amino compounds and have great potential for future applications. Exploitation of the carbazole strategy for the generation of novel multicyclic structures and their biological evaluation is currently under way.

Experimental Section

Melting points were determined at atmospheric pressure and uncorrected. Proton and carbon NMR spectra were recorded at 300 and 75 MHz, respectively, using TMS as an internal standard and $CDCl_3$ as the solvent. Thin-layer chromatography was performed on an SiO_2 plate, and the spots were detected in a UV viewing or iodine chamber. Dichloromethane and THF were used directly without purification or drying. All of the extracts were dried over anhydrous Na_2 SO_4.

Method 1: General Procedure for the Synthesis of Pyrroles (3). Montmorillonite KSF clay (1 g), hexane-2,5-dione (**2**) (114 mg, 1 mmol), and the appropriate amine **1** (1.2 mmol) were mixed together thoroughly using dichloromethane (1 mL). The solvent was then evaporated, and the mixture was kept at room temperature for a period specified in Table 1. After this period, the solid mixture was washed with dichloromethane and the washings were evaporated to obtain pyrrole.

Method 2: General Procedure for the Synthesis of Pyrroles (3). To a solution of the amine **1** (1 mmol) and hexane-2,4-dione **2** (1.2 mmol) in THF (5 mL) at room temperature was added iodine (0.1 mmol). The mixture was stirred at this temperature for a period specified in Table 2. Dichloromethane (20 mL) was then added to the mixture. The resulting mixture was washed successively with 5% $Na_2S_2O_3$ solution (2 mL), saturated $NaHCO_3$ solution (2 mL), and brine (2 mL). The organic layer was then dried with sodium sulfate and concentrated. These pyrroles were found to be sufficiently pure (more than 90%).

For a relatively large-scale reaction (5−10 g), a different experimental procedure was adopted. If one of the reactants was a liquid, the experiment was conducted without using solvent (Table 2, entries 9, 10, 12−15). If the reaction mixture was a very thick slurry, addition of a small amount of ordinary THF or dichloromethane was necessary to ensure a better outcome of the reaction (Table 2, entries 3−7). After the reaction, it was necessary to extract the reaction mixture.

1-Phenyl-2,5-dimethylpyrrole (3a). A 93 mg (1 mmol) portion of aniline was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 154 mg (90%) of pure 1-phenyl-2,4-dimethyl pyrrole. ^{1}H NMR (300 MHz): δ 2.05 (6H, s), 5.93 (2H, s), 7.22−7.25 (2H, m), 7.43−7.50 (3H, m). Anal. Calcd for $C_{12}H_{13}N$: C, 84.16; H, 7.65; N, 8.18. Found: C, 79.91; H, 7.50; N, 8.02.

1-Benzyl-2,5-dimethylpyrrole (3i). A 107 mg (1 mmol) portion of benzylamine was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 170 mg (92%) of pure 1-benzyl-2,4-dimethylpyrrole. ^{1}H NMR (300 MHz): δ 2.17 (6H, s), 5.03 (2H, s), 5.89 (2H, s), 6.90−6.92 (2H, m), 7.22−7.37 (3H, m). Anal. Calcd for $C_{13}H_{15}N$: C, 84.39; H, 8.16; N, 7.56. Found: C, 84.40; H, 8.21; N, 7.56.

1-(1-Naphthalenyl)-2,5-dimethylpyrrole (3c). A 143 mg (1 mmol) portion of 1-naphthylamine was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 188 mg (85%) of pure 1-(1-naphthyl)-2,4-dimethylpyrrole. Mp: 118 °C. IR: 3062, 1595, 1578, 1522, 1508, 1468, 1435 cm^{-1}. ^{1}H NMR (300 MHz): δ 1.89 (6H, s), 6.00 (2H, s), 7.13 (1H, d, J = 8.34 Hz), 7.39−7.57 (4H, m), 7.91 (2H, d, J = 8.25 Hz). Anal. Calcd for $C_{16}H_{15}N$: C, 86.83; H, 6.83; N, 6.32. Found: C, 86.50; H, 6.51; N, 6.20.

1-(1-Anthracenyl)-2,5-dimethylpyrrole (3d). A 193 mg (1 mmol) portion of 1-aminoanthracene was reacted with 138.8 mg

(1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 238 mg (88%) of pure 1-(1-anthryl)-2,4-dimethyl pyrrole. Mp: 182−183 °C. ^{1}H NMR (300 MHz): δ 1.93 (6H, s), 6.06 (2H, s), 7.38−7.55 (4 H, m), 7.71 (1H, s), 7.90 (1H, d, J = 7.95 Hz), 8.01 (1H, d, J = 7.98 Hz), 8.09 (1H, d, J = 8.55 Hz) 8.51 (1H, s). Anal. Calcd for $C_{20}H_{17}N$: C, 88.52; H, 6.31; N, 5.16. Found: C, 88.61; H, 6.21; N, 5.01.

1-(9-Phenanthrenyl)-2,5-dimethylpyrrole (3e). A 193 mg (1 mmol) portion of 1-aminophenanthrene was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 247 mg (91%) of pure 1-(9-phenanthrenyl)-2,4-dimethyl pyrrole. Mp: 154−156 °C. ^{1}H NMR (300 MHz): δ 1.94 (6H, s), 6.03 (2H, s), 7.11 (1H, d, J = 8.06 Hz), 7.53−7.75 (5H, m), 7.92 (1H, d, J = 7.50 Hz), 8.73 (2H, d, J = 8.30 Hz). Anal. Calcd for $C_{20}H_{17}N$: C, 88.52; H, 6.31; N, 5.16. Found: C, 88.43; H, 6.12; N, 4.99.

1-(1-Pyrenyl)-2,5-dimethylpyrrole (3f). A 217 mg (1 mmol) portion of 1-aminopyrene was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 257 mg (87%) of pure 1-(1-pyrenyl)-2,4-dimethylpyrrole. Mp: 145 °C. IR (CH_2Cl_2): 3043, 1602, 1489, 1510, 1458, 1409 cm^{-1}. ^{1}H NMR (300 MHz): δ 1.92 (6H, s), 6.08 (2 H, s), 7.39 (1H, d, J = 9.10 Hz), 7.90 (1H, d, J = 8.01 Hz), 8.04−8.27 (7H, m). Anal. Calcd for $C_{22}H_{17}N$: C, 89.45; H, 5.80; N, 4.74. Found: C, 89.17; H, 5.70; N, 4.69.

1-(6-Chrysenyl)-2,5-dimethylpyrrole (3g). A 243 mg (1 mmol) portion of 6-aminochrysene was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 257 mg (80%) of pure 1-(6-chrysenyl)-2,4-dimethylpyrrole. Mp: 225−226 °C. ^{1}H NMR (300 MHz): δ 1.97 (6H, s), 5.99 (2H, s), 7.25 (1 H, m), 7.58−7.74 (4H, m), 8.03 (1H, m), 8.08 (1 H, d, J = 9.09 Hz), 8.69 (2H, m), 8.76 (1H, d, J = 9.10 Hz), 8.84 (1H, d, J = 8.20 Hz). Anal. Calcd for $C_{24}H_{19}N$: C. 89.68; H, 5.95; N, 4.35. Found: C, 89.49; H, 6.12; N, 4.10.

1-(4-Methoxyphenyl)-2,5-dimethylpyrrole (3b). A 123 mg (1 mmol) portion of *p*-anisidine was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 169 mg (84%) of pure 1-(4-methoxyphenyl)-2,4-dimethylpyrrole. ^{1}H NMR (300 MHz): δ 2.02 (6H, s), 3.85 (3H, s), 5.88 (2 H, s), 6.97 (2H, d, J = 8.89 Hz), 7.13 (2H, d, H = 8.90 Hz). Anal. Calcd for $C_{13}H_{15}NO$: C, 77.58; H, 7.51; N, 6.95. Found: C, 77.46; H, 7.43; N, 6.83.

1-(2-Aminopyridyl)-2,5-dimethylpyrrole (3j). A 94 mg (1 mmol) portion of 2-aminopyridine was reacted with 138.8 mg (1.2 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 175 mg of crude product. It was purified by column chromatography using 10% ethyl acetate and 90% hexane to afford 134 mg (78%) of pure 1-(2-aminopyridyl)-2,4-dimethyl pyrrole. ^{1}H NMR (300 MHz): δ 2.12 (6H, s), 5.90 (2 H, s), 7.29 (2H, d, m), 7.82 (1H, m), 8.60 (1H, m). Anal. Calcd for $C_{11}H_{12}N_2$: C, 76.71; H, 7.02; N, 6.95. Found: C, 76.80; H, 6.95; N, 6.83.

1,5-Diphenyl-2-methylpyrrole (3k). Yield: 91%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.13 (3H, s), 6.08 (1H, dd, J = 0.9, 3.6 Hz), 6.34 (1H, d, J = 3.3 Hz), 7.03−7.16 (H, m), 7.30−7.34 (3H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 13.7, 107.9, 109.1, 126.0, 127.82, 128.2, 128.3, 128.9, 129,20, 129.3, 132.1, 133.9, 134.6, 139.8. Anal. Calcd for $C_{17}H_{17}N$: C, 86.76; H, 7.28; N, 5.95. Found: C, 86.57; H, 7.00; N, 6.12.

1-Benzyl-2-methyl-5-phenylpyrrole (3l). Yield: 89%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.12 (3H, s), 5.11 (2H, s), 6.03 (1H, dd, J = 0.9. 3.3 Hz), 6.22 (1H, d, J = 3.6 Hz), 6.92 (2H, m), 7.20−7.30 (8H, m). ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.0, 48.1, 107.7, 108.4, 126.1, 127.1, 127.4, 127.7, 128.8, 129.11, 129.2, 130.8, 134.2, 135.1, 139.4. Anal. Calcd for $C_{18}H_{17}N$: C, 87.40; H, 6.92; N, 5.66. Found: C, 87.30; H, 6.75; N, 5.48.

1-(1-Butyl)-2-methyl-5-phenylpyrrole (3m). Yield: 93%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.79 (3H, t, J = 6 Hz), 1.18 (2H, m), 1.52 (2H, m), 2.30 (3 H, s), 3.82 (2H, m), 5.93 (1H, d, J = 3.3 Hz), 6.08 (1H, d, J = 3.3 Hz), 7.23−7.30 (1H, m), 7.36 (4H, m). Anal. Calcd for $C_{15}H_{19}N$: C, 84.45; H, 8.97; N, 6.56. Found: C, 84.40; H, 8.81; N, 6.42.

1-Cyclopentyl-2-methyl-5-phenylpyrrole (3n). Yield: 76%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.58 (2H, m), 1.82 (2H, m), 1.99 (4 H, m), 2.42 (3H, s), 4.65(1 H, m), 5.96 (1H, d, J = 3.3 Hz), 6.01 (1H, d, J = 3.3 Hz), 7.35 (5H, m). Anal. Calcd for $C_{16}H_{19}N$: C, 85.28; H, 8.49; N, 6.21. Found: C, 85.24; H, 8.66; N, 6.11.

1, 2, 3, 5-Tetraphenylpyrrole (3o). Yield: 15%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.0 (1H, s), 6.96−7.05 (4H, m), 7.10−7.21 (13H, m), 7.22−7.25 (3H, m).

Bis-pyrrole (3h). A 60 mg (1 mmol) portion of ethylenediamine was reacted with 278 mg (2.4 mmol) of hexane-2,4-dione in the presence of 26 mg (0.1 mmol) of iodine to afford 192 mg (89%) of pure 1-(4-methoxyphenyl)-2,4-dimethylpyrrole as an oil. ^{1}H NMR (300 MHz): δ 2.00 (12H, s), 3.92 (4H, s), 5.80 (4H, s). Anal. Calcd for $C_{14}H_{20}N_2$: C, 77.72; H, 9.31; N, 12.95. Found: C, 77.48; H, 9.11; N, 12.79.

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