# Green Synthesis of 1-(1,2,4-Triazol-4-yl)spiro[azetidine-2,3′-(3*H*)indole]-2′,4′(1′*H*)-diones as Potential Insecticidal Agents



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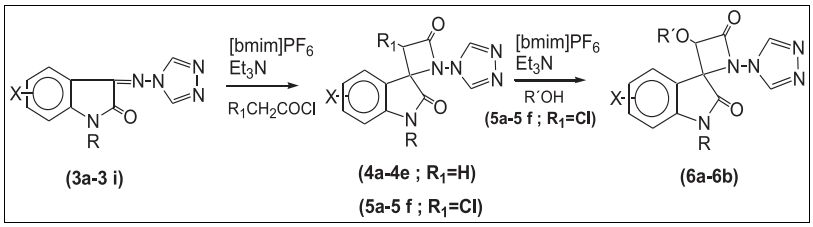


One pot green synthesis of 1-(1,2,4-triazol-4-yl)spiro[azetidine-2,3′-(3*H*)-indole]-2′,4′(1′*H*)-diones was carried out by the reaction of indole-2,3-diones,4-amino-4*H*-1,2,4-triazole and acetyl chloride/chloroacetyl chloride in ionic liquid [bmim]$PF_6$ with/without using a catalyst. It was also prepared by conventional method *via* Schiff's bases, 3-[4*H*-1,2,4-triazol-4-yl]imino-indol-2-one. Further, the corresponding phenoxy derivatives were obtained by the reaction of chloro group attached to azetidine ring with phenols. The synthesized compounds were characterized by analytical and spectral (IR, $^1$H NMR, $^{13}$C NMR, and FAB mass) data. Evaluation for insecticidal activity against *Periplaneta americana* exhibited promising results.

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## INTRODUCTION

Heterocyclic scaffolds represent the central frame work of many biologically active compounds. Among the various heterocyclic systems, indole holds a prominent position because of its presence as a core unit in a number of compounds possessing broad spectrum of biological activities [1]. Indole-2,3-dione derivatives act as anticancer [2] and antihistaminic agents [3]. 1,2,4-Triazole with an extra nitrogen atom behaves like pyridine so weakly basic and is important as it is the basis of best modern agricultural fungicides [4] as well as drugs for fungal diseases in humans. A recent example of this is Pfizer's fluconazole, the Schiff's base with isatin, which exhibits antimicrobial activity [5]. β-Lactams (azetidinones) are the key components of many biologically active compounds such as penicillin and cephalosporin antibiotics [6–8] and show antibacterial [9], antifungal [9], and anti-inflammatory [10] activities. These are also used to inhibit cholesterol absorption [11].

The chemistry of spiro indoles in which an indole ring is joined to nitrogen containing heterocycles at C-3 position through a spiro carbon atom has aroused great interest due to their physiological and biological activities [10]. Amongst these spiro[azetidine-indole] are known to possess antimicrobial activity [12,13]. It was therefore, presumed that the title molecules incorporating indole, azetidinone, and triazole moieties would have enhanced biological properties. The investigation further appeared interesting because the insecticidal data on 2-azetidinones are scanty in the published reports.

In recent years, use of ionic liquids (ILs), which are organic salts where ions do not pack well and remain liquid at room temperature have emerged. These have unique properties such as wide liquid range, good solvency, tunable polarity, high thermal stability, negligible vapor pressure, and ease of recyclability and hence can be reused as opposed to the traditional solvent catalyst systems.

Although few references [14–16] regarding synthesis of azetidinone derivatives in ionic liquid are available but synthesis of spiro [azetidine–indole] system in ionic liquid has not been reported.

With a view to develop an efficient, economical, and extremely fast procedure using green chemistry concept 1-(1,2,4-triazol-4-yl)spiro[azetidine-2,3′-[3*H*]indole]-2′-4′(1′*H*)-diones **4** and **5** were synthesized by the reaction of indole-2,3-diones **1**, 4-amino-4*H*-1,2,4-triazole **2** and acetyl chloride/chloroacetylchloride in ionic liquid [bmim]$PF_6$ with or without using catalyst for the first time by the authors. Simultaneously, these were also prepared by conventional method *via* Schiff's bases [13,17], 3-[4*H*-1,2,4-triazol-4-yl]-imino-indol-2-one **3** obtained by the reaction of **1** and **2**. In the second step, **3** were reacted with acetyl chloride/chloroacetylchloride to give **4** and **5.** Alternatively, the title compounds **4** and **5** have also been prepared without isolating the Schiff's bases and cyclized *in situ* with acetyl chloride/chloro acetyl chloride.

Formation of Schiff's bases was investigated in various solvents, *viz.* glc. AcOH, ethanol-glc. AcOH, toluene-glc. AcOH, and DMF [10,13]. It was observed that DMF was the best solvent for this reaction with no need of catalyst and higher yield was obtained. Further, the reaction with phenols resulted in nucleophilic substitution of the -Cl group attached to azetidinone ring to give the 3-phenoxy derivatives [18] (Scheme 1).

## RESULTS AND DISCUSSION

Azetidine derivatives were prepared by two methods.

1. **Conventional method**
   In this two procedures were used:
   - **Method A**
     First, the Schiff's bases were prepared and isolated (70–80%) and in the second step, these were reacted with acetyl chloride/chloroacetylchloride. The yields were 50–60%.
   - **Method B**
     Schiff's bases prepared by method A were not isolated and acetyl chloride/chloroacetylchloride was added in the same flask and refluxed further (65–70%).

2. **Ionic liquid mediated method**

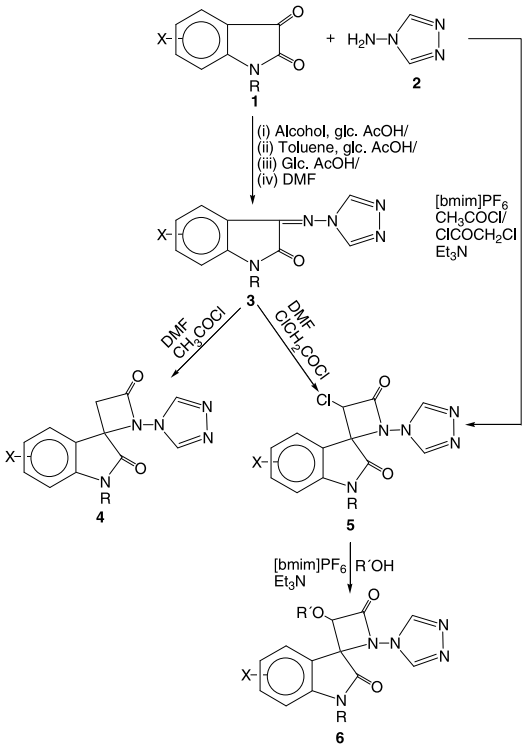
In this one pot synthesis indole-2,3-diones, 4-amino-4*H*-1,2,4-triazole, and acetyl chloride/chloroacetylchloride were heated in ionic liquid [bmim]$PF_6$ for 2 h, with or without the catalyst, $Et_3N$. Yield is much better (90–95%) in the presence of catalyst, which was (80–85%) without it.

Azetidine derivatives prepared by either method have same analytical and spectral data. The formation of Schiff's bases were characterized by IR spectrum, which show characteristic C═N stretching vibration at 1620 $cm^{-1}$ with the disappearance of vibration at 1750 $cm^{-1}$ (>C═O of isatin at C-3). In the $^1$H NMR spectrum, it shows disappearance of peak due to amino group of 4-amino-4*H*-1,2,4-triazole observed from δ 4.8 to 5.2 ppm. In $^{13}$C NMR, the peaks appeared at δ 148.0 (triazole C-3) and δ 149.0 (triazole C-5) ppm besides the indoline carbon atoms.

The formation of Mannich bases from Schiff's bases were characterized by the disappearance of peak at 3200 $cm^{-1}$ due to >NH of indole of Schiff's bases in IR spectrum. In $^1$H NMR, the peak at δ 10–11 ppm (>NH) disappeared along with the appearance of peak due to —$CH_2$—N< at δ 4.36 ppm (s, 2H, $CH_2$). In $^{13}$C NMR characteristic >N—$CH_2$N<, signal belonging to the Mannich bases was observed at δ 171.0 ppm. In the mass spectrum, it shows $M^+$ at *m/z* 213 (**3a**).

Formation of azetidine derivatives by $CH_3COCl$ was characterized by IR absorption band at 1690 $cm^{-1}$ ($COCH_2$ of monocyclic β-lactam ring). In $^1$H NMR, characteristic

**Scheme 1**




| Compd. | X | R | Compd. | X | R | Compd. | X | R | R´ |
|---|---|---|---|---|---|---|---|---|---|
| **3a** | H | H | **3h** | H | $CH_2N$ | **5a** | H | H | - |
| **3b** | 5-Cl | H | **3i** | H | $-COCH_3$ | **5b** | 5-Cl | H | - |
| **3c** | 5-F | H | **4a** | H | H | **5c** | 5-F | H | - |
| **3d** | H | $CH_3$ | **4b** | 5-Cl | H | **5d** | H | $CH_3$ | - |
| **3e** | H | $CH_2Ph$ | **4c** | 5-F | H | **5e** | H | $CH_2Ph$ | - |
| **3f** | H | $CH_2NMe_2$ | **4d** | H | $CH_3$ | **5f** | H | $CH_2NMe_2$ | - |
| **3g** | H | $CH_2NEt_2$ | **4e** | H | $CH_2NMe_2$ | **6a** | H | H | 4-$NO_2$–Ph |
| | | | | | | **6b** | H | H | 2-Naphthyl |

peak appeared at δ 2.2 ppm (s, 2H, $CH_2$). $^{13}C$ NMR exhibited peaks at δ 46.0 and 165.6 ppm for $\underline{C}H_2CO$ and $\underline{C}O$ of azetidinone ring. Further, in mass spectrum, peak appeared at $M^+$ at *m/z* 255 **(4a)**.

Formation of azetidine derivatives by $ClCOCH_2Cl$ was characterized by IR absorption band at 1705 $cm^{-1}$ (CO mononcyclic β-lactam ring) and 750–780 $cm^{-1}$ (C—Cl group) and $^1H$ NMR signal at δ 4.35 ppm (s, 1H, CH). $^{13}C$ NMR shows peaks at δ 167.2 ppm and δ 127.0 ppm for >C═O and CH—Cl of azetidinone ring. Further, in the mass spectrum it shows $M^+$ at *m/z* 289.5 **(5a)**.

Since the —Cl group attached to azetidinone ring is very reactive and on reacting with phenols, it gave phenoxy derivative. The formation of phenoxy derivative was confirmed by IR spectrum which show peak at 750–780 $cm^{-1}$ (for C—Cl group) disappeared and bands at 1225–1200 and 1075–1020 $cm^{-1}$ appears for C—O—C asymmetrical and symmetrical stretching, respectively. In the $^1H$ NMR, the CH-Cl signal (δ 4.35 ppm) shifted downfield for —OCH—O—R (δ 4.81 ppm). $^{13}C$ NMR shows peak at δ 158.9 ppm for >$\underline{C}$H—OR. Mass spectrum shows $M^+$ at (m/z) 392 **(6a)**.

## INSECTICIDAL ACTIVITY

For insecticidal activity [19, 20], *Periplaneta americana* was taken and where 1 and 2% solutions of prepared compounds were injected in the abdominal region of the cockroach with the help of microsyringe. At the time of death, the antennae become motionless, the appendages shrunk, and folded toward central side and the cockroach lay dorsally, which was noted as KD (knock down) value. The KD value of synthesized heterocyclic derivatives was compared with control drug (cypermethrin). Results have been recorded in Table 1.

It was observed that compounds having fluoro and chloro group exhibited better insecticidal activity (KD value is 3–5 min) in comparison to standard drug (KD value is 5–7 min). Rest of the compounds have significant to moderate activity (KD value is 6–11 min).

**Table 1**

Insecticidal activity of the synthesized compounds against *Periplaneta americana* (KD value in min).

| | Time (min) | |
|---|---|---|
| Compound | 1% (conc.) | 2% (conc.) |
| **3a** | 10 | 7 |
| **3b** | 7 | 6 |
| **3c** | 6 | 4 |
| **3d** | 9 | 6 |
| **3e** | 10 | 8 |
| **3f** | 9 | 7 |
| **3g** | 9 | 6 |
| **3h** | 10 | 8 |
| **3i** | 10 | 9 |
| **4a** | 11 | 8 |
| **4b** | 7 | 5 |
| **4c** | 6 | 4 |
| **4d** | 11 | 8 |
| **4e** | 9 | 8 |
| **5a** | 9 | 7 |
| **5b** | 6 | 4 |
| **5c** | 5 | 3 |
| **5d** | 8 | 6 |
| **5e** | 9 | 7 |
| **5f** | 10 | 8 |
| **6a** | 8 | 6 |
| **6b** | 9 | 6 |
| Std | 7 | 5 |

Std – cypermethrin.

## CONCLUSION

In conclusion, the presented method (ILs) provided an environmental friendly, efficient, and convenient procedure to synthesize azetidinones in the presence of $Et_3N$ and $[bmim]PF_6$ avoiding the use of a large amount of organic solvents. Further, nucleophilic substitution reaction of –Cl group of azetidinone ring was carried out using various phenols. Some of the synthesized compounds may be developed as good insecticidal agents.

## EXPERIMENTAL

Melting points are uncorrected and were taken in open glass capillaries using Gallenkamp melting point apparatus. The IR spectra were recorded on a 800S SHIMADZU IR spectrometer in KBr pellets and band positions are reported in wave numbers ($cm^{-1}$). The $^1H$ NMR spectra and $^{13}C$ NMR spectra have been recorded on JEOL 300 MHz in DMSO-$d_6$/$CDCl_3$. Chemical shifts (δ) are given in ppm. The mass spectra were recorded on JEOL SX 102 (FAB). Elemental analyses were performed at Central Drug Research Institute, Lucknow, India. Commercially available (ACROS) ionic liquid $[bmim]PF_6$ was used for the reactions.

**Indole-2,3-diones 1.** These were prepared by following the published report method [21,22].

**Conventional method for the synthesis of 3a-3i, 4a–4e, and 5a–5f**

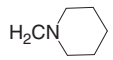
- **Method A**

**1. 3-[4H-1,2,4-Triazol-4-yl]-imino-indol-2-one (3a)**

Equimolar quantities (0.01 mol) of indole-2,3-dione and 4-amino-4*H*-1,2,4-triazole were dissolved in DMF (5 mL) [13,23]. The reaction mixture was refluxed for 6 h and then kept at room temperature overnight. The resultant solid was washed with ethanol, dried, and recrystallized from ethanol–water mixture to give the Schiff's bases, orange in color yield 80%; m.p. 230°C; IR (KBr $cm^{-1}$) $\nu_{max}$: 3320 (>NH), 1650 (CONH), 1620 (C═N); $^1H$ NMR (300 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 6.95–7.48 (m, 4H, Ar-H), 8.25 (s, 2H, -CH of triazole), 9.02 (br, 1H, >NH); $^{13}C$ NMR (75 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 121.6–137.8 (aromatic carbons), 148.0 (C-3 triazole), 149.0 (C-5 triazole), 164.2 (>C═N), 168.2 (>C═O); MS (m/z): 213 ($M^+$), Anal. Calcd. for $C_{10}H_7N_5O$; C, 56.34; H, 3.29; N, 32.86, Found C, 56.38; H, 3.34; N, 32.82%.

**Table 2**

Physical and analytical data of the compounds synthesized.

| Compd. No. | X | R | $R^1$ | Yield (%) Conv. | Yield (%) IL | Mol. 34formula | M.P. (°C) | Analysis % Calcd. (Found) C | H | N |
|---|---|---|---|---|---|---|---|---|---|---|
| **3a** | H | H | – | 80 | – | $C_{10}H_7N_5O$ | 230 | 56.34 (56.38) | 3.29 (3.34) | 32.86 (32.82) |
| **3b** | 5-Cl | H | – | 75 | – | $C_{10}H_6N_6OCl$ | 192 | 48.48 (48.45) | 2.42 (2.47) | 28.28 (28.29) |
| **3c** | 5-F | H | – | 73 | – | $C_{10}H_6N_5OF$ | 187 | 51.94 (51.90) | 2.59 (2.62) | 30.30 (30.33) |
| **3d** | H | $CH_3$ | – | 76 | – | $C_{11}H_9N_5O$ | 195 | 58.14 (58.11) | 3.96 (4.01) | 30.83 (30.87) |
| **3e** | H | $CH_2Ph$ | – | 72 | – | $C_{17}H_{13}N_5O$ | 146 | 67.32 (67.36) | 4.29 (4.31) | 23.10 (23.14) |
| **3f** | H | $CH_2NMe_2$ | – | 77 | – | $C_{13}H_{14}N_6O$ | 178 | 57.78 (57.81) | 5.18 (5.14) | 31.11 (31.15) |
| **3g** | H | $CH_2NEt_2$ | – | 70 | – | $C_{15}H_{18}N_6O$ | 211 | 60.40 (60.44) | 6.04 (6.09) | 28.19 (28.24) |
| **3h** | H |  | – | 74 | – | $C_{16}H_{18}N_6O$ | 237 | 61.94 (61.91) | 5.81 (5.85) | 27.09 (27.11) |
| **3i** | H | $COCH_3$ | – | 79 | – | $C_{12}H_9N_6O_2$ | 205 | 56.47 (56.46) | 3.53 (3.57) | 27.45 (27.41) |
| **4a** | H | H | – | 70 | 95 | $C_{12}H_9N_5O_2$ | 154 | 56.47 (56.44) | 3.53 (3.49) | 27.45 (27.43) |
| **4b** | 5-Cl | H | – | 65 | 94 | $C_{12}H_8N_5O_2Cl$ | 208 | 49.74 (49.72) | 2.76 (2.74) | 24.18 (24.20) |
| **4c** | 5-F | H | – | 62 | 90 | $C_{12}H_8N_5O_2F$ | 182 | 49.74 (49.70) | 2.93 (2.90) | 25.64 (25.68) |
| **4d** | H | $CH_3$ | – | 66 | 94 | $C_{13}H_{11}N_5O_2$ | 158 | 52.75 (52.74) | 4.09 (4.11) | 26.02 (26.06) |
| **4e** | H | $CH_2NMe_2$ | – | 64 | 92 | $C_{15}H_{16}N_6O_2$ | 164 | 57.69 (57.71) | 5.12 (5.09) | 26.92 (26.88) |
| **5a** | H | H | – | 69 | 90 | $C_{12}H_8N_5O_2Cl$ | 138 | 49.74 (49.70) | 2.76 (2.80) | 24.15 (24.18) |
| **5b** | 5-Cl | H | – | 70 | 92 | $C_{12}H_7N_5O_2Cl_2$ | 282 | 44.44 (44.48) | 2.16 (2.14) | 21.60 (21.55) |
| **5c** | 5-F | H | – | 65 | 93 | $C_{12}H_7N_5O_2ClF$ | 112 | 46.83 (46.80) | 2.27 (2.30) | 22.76 (22.81) |
| **5d** | H | $CH_3$ | – | 62 | 94 | $C_{13}H_{10}N_5O_2Cl$ | 108 | 51.40 (51.44) | 3.29 (3.24) | 23.06 (23.03) |
| **5e** | H | $CH_2Ph$ | – | 64 | 90 | $C_{19}H_{14}N_5O_2Cl$ | 90 | 60.08 (60.12) | 3.69 (3.66) | 18.44 (18.46) |
| **5f** | H | $CH_2NMe_2$ | – | 61 | 92 | $C_{15}H_{15}N_6O_2Cl$ | 118 | 51.95 (51.99) | 4.33 (4.29) | 24.24 (24.21) |
| **6a** | H | H | 4-$O_2NC_6H_4$- | – | 92 | $C_{18}H_{12}N_6O_5$ | 181 | 55.10 (55.14) | 3.06 (3.05) | 21.42 (21.47) |
| **6b** | H | H | 2–Naphthyl- | – | 90 | $C_{22}H_{15}N_5O_3$ | 190 | 66.49 (66.44) | 3.78 (3.80) | 17.63 (17.62) |

Compounds **3b–3i** have been prepared similarly, their physical and analytical data are recorded in Table 2.

**2. 1-(1,2,4-Triazole-4-yl)spiro[azetidine-2,3′(3*H*)indole]-2′,4′-(1′*H*)-diones (4a)**

To a solution of Schiff's base (0.01 mol) in DMF (10 mL), acetyl chloride [24] (0.01 mol) and triethylamine (0.01 mol) were added and the reaction mixture was stirred at room temperature for 24 h. The reaction mixture was poured into ice cold water and liberated compounds were extracted with chloroform. Solvent was evaporated under reduced pressure and recrystallized with ethyl acetate to give **4a** in 60% yield, m.p. 154°C; IR(KBr $cm^{-1}$) $\nu_{max}$: 3380 (>NH), 1660 (C=O, azetidine), 1630 (CONH); $^1$H NMR (300 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 3.21(s, 2H, $CH_2CO$), 6.50–7.55 (m, 4H, Ar-H), 8.01 (s, 2H, =CH), 9.23 (br, 1H, >NH); $^{13}$C NMR (75 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 86.5 (spiro C-3), 46.8 ($\underline{C}H_2CO$), 121.8–138.5 (aromatic carbons), 148.0 (C-3, triazole), 149.0 (C-5, triazole), 165.6 ($CH_2\underline{C}O$)), 168.0 (NH$\underline{C}$O); MS (*m/z*): 255 ($M^+$), Anal. Calcd. for $C_{12}\underline{H}_9N_5O_2$: C, 56.47; H, 3.53; N, 27.45. Found: C, 56.44; H, 3.49; N, 27.43%.

Compounds **4b–4e** have been prepared, similarly, their physical and analytical data are recorded in Table 2.

**3. 3-Chloro-1-(1,2,4-triazole-4-yl)spiro[azetidine-2,3′(3H) indole]- 2′,4′-(1′H)-diones (5a)**

It was prepared similarly as **4a** taking **3a** and chloroacetylchloride yield 60%, m.p. 138°C. IR (KBr $cm^{-1}$) $\nu_{max}$: 3290 (>NH), 1705 (C=O, azetidine), 1690 (CONH), 780 (C-Cl); $^1$H NMR (300 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 4.35 (s, 1H, CH-Cl), 6.95–7.81 (m, 4H, ArH), 8.21 (s, 2H, =CH, triazole), 9.02 (s, 1H, >NH); $^{13}$C NMR (75 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 86.8 (spiro C-3), 122.1–138.2 (aromatic carbons), 127.0 (CH-Cl), 148.0 (C-3 triazole), 149.0 (C-5, triazole), 165.4 (ClCH-$\underline{C}$O), 169.3 (NH$\underline{C}$O); MS (*m/z*): 289.5 ($M^+$), Anal. Calcd. for $C_{12}\underline{H}_8N_5O_2Cl$: C, 49.74; H, 2.76; N, 24.15. Found: C, 49.70; H, 2.80; N, 24.18%.

Compounds **5b–5f** have been prepared, similarly, their physical and analytical data are recorded in Table 2.

- **Method B**

A mixture of indole-2,3-dione (0.01 mol) and 4-amino-4*H*-1,2,4-triazole (0.01 mol) was refluxed in DMF (10 mL) for 2 h with few molecular sieves $4A^0$ size to absorb a theoretical amount of the water formed. On cooling of the mixture, acetyl chloride/chloroacetylchloride (0.01 mol) and $Et_3N$ (0.01 mol) were added and the resultant mixture refluxed further for 2 h. The reaction mixture was cooled, poured into ice cold water, and liberated compound was extracted with chloroform. Solvent was evaporated under reduced pressure and recrystallized by ethyl acetate or purified by column chromatography over silica gel using ethylacetate/benzene = 3:7 as an eluent yield 65–70%. Compounds **4b–4e** and **5b–5f** have been prepared, similarly, their physical and analytical data are the same as in method A.

## IONIC LIQUID MEDIATED ONE POT SYNTHESIS OF 4a–4e AND 5a–5f

A mixture of indole-2,3-dione (0.01 mol), 4-amino-4*H*-1,2,4-triazole (0.01 mol), and ionic liquid [bmim]$PF_6$ (5 mL) were taken in a round-bottomed flask and heated

at 60–70°C under $N_2$ protection [16] for 1 h. On cooling at room temperature (after 15 min) acetyl chloride/chloroacetylchloride (0.01 mol) and triethylamine (0.01 mol) were injected and stirred for 15 min at room temperature thereafter, the temperature was raised to 60°C and the mixture was stirred further for 2 h. The progress of the reaction was monitored by TLC. After completion of reaction, the mixture was extracted with ether (6 × 10 mL). The organic extract was washed with 5% $Na_2CO_3$ (40 mL) and water (40 mL), dried with anhydrous magnesium sulfate and evaporated *in vacuo*. The residual product was purified by recrystallization from AcOEt/cyclohexane or by column chromatography (silica gel, 200–300 mes, eluent, cyclohexane/AcOEt = 4:1) to give **4a–4e**, **5a–5f** in 90–95% yield. The ionic liquid layer was washed with water (3 × 5 mL) and kept for 2 h at 80–85°C under reduced pressure. The ionic liquid was reused for further synthesis of other compounds.

The physical, analytical, and spectral data are the same as prepared by conventional method.

**Recovery of the ionic liquid.** An attempt was made to recover the ionic liquid. After completion of the reaction, the reaction mixture was poured into ice water, and the product was filtered-off. The filtrate was extracted with ethyl acetate to recover unreacted reactants, and the aqueous layer was subjected to evaporation of water to get viscous liquid, which on cooling, gave the ionic liquid. The recovered ionic liquid was reused for two more cycles of the same cyclocondensation and found to act satisfactorily.

**3-*p*-Nitrophenoxy-1-(1,2,4-triazol-4-yl)spiro[azetidine-2,3′[3*H*]indole-2′,4′(1′*H*)]-dione (6a).** An equimolar (0.002 mol) mixture of **5a** and *p*-nitrophenol in ionic liquid [bmim]$PF_6$ (5 mL) containing $Et_3N$ (0.003 mol) was refluxed for 2 h. The progress of reaction was checked by TLC. After completion of reaction it was worked up as described for **5a**, yield 92% m.p. 181°C; IR (KBr $cm^{-1}$) $\nu_{max}$: 3310 (>NH), 1700 (C═O, azetidine), 1680 (CONH), 1355 ($NO_2$ of phenyl), 1255 (C-O-C, asymmetrical stretching), 1075 (C-O-C, symmetrical stretching); $^1$H NMR (300 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 4.81 (s, 1H, -O-CH-OR), 6.85–7.83 (m, 8H, ArH), 8.32 (s, 2H, ═CH, triazole); 9.30 (s, 1H, >NH); $^{13}$C NMR (75 MHz, $CDCl_3$ + DMSO-$d_6$), δ ppm: 90.2 (spiro C-3), 122.2–138.9 (aromatic carbons), 148.0 (C-3 of triazole), 149.0 (C-5, triazole), 158.9 (-O-CH-$OC_6H_4NO_2$), 165.6 (-O-CH-CO), 169.8 (>NHCO); MS (*m/z*): 392 ($M^+$). Anal. Calcd. for $C_{18}H_{12}N_6O_5$: C, 55.10; H, 3.06; N, 21.42. Found: C, 55.14; H, 3.05; N, 21.47%. Compound **6b** was prepared, similarly, its data are recorded in Table 2.

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