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Original article

Synthesis and antibacterial activity of various substituted *s*-triazines

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Abstract

Series of substituted-*s*-triazines (**1**–**22**) were synthesized and evaluated for their in vitro antibacterial activity against six representative Gram-positive and Gram-negative bacterial strains. Many compounds have displayed comparable antibacterial activity against *Bacillus sphaericus* and significantly active against other tested organisms with reference to streptomycin.

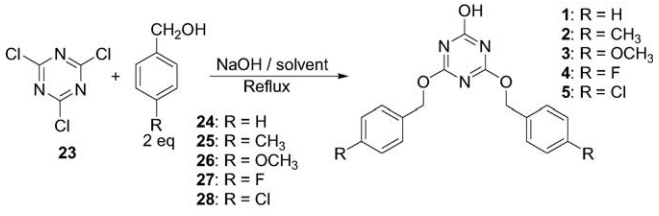
Keywords: s-Triazine derivatives; Synthesis; Antibacterial activity; Antifungal activity

1. Introduction

The rapid development of pathogen resistance to most of the known antibiotics is becoming a serious health problem [1–3]. Many groups have been working in solving the antibacterial resistance problems [4–11]. One possible long-term solution is the development of agents that act on unexploited antibacterial targets [11]. In view of the above, the design and synthesis of effective and potent antimicrobials is an area of immense significance for medicinal chemists [1–11]. In this context, *s*-triazine derivatives have received considerable attention due to its potent biological activity such as anti-protozoals [12], anticancer [13], estrogen receptor modulators [14], antimalarials [15,16], Cyclin-dependent kinase inhibitors [17] and antivirals [18]. It has been reported that *s*-triazine derivatives possess potent antimicrobial activity [19–23]. Besides, many of the imidazole containing compounds exhibited the antibacterial activities [24–26]. Our undiminished interest in this area is to design and synthesize diverse biologically active heterocyclic compounds [19,27]. As part of our continuous effort, here we report the synthesis and antibacterial activity of a variety of *s*-triazine derivatives.

2. Chemistry

The compounds **1**–**22** were synthesized to understand the role of mono, di and tri-substitution, 4-substituted benzyloxy, 4-imidazoloaniline, chiralbenzylamine and styryl groups on triazine moiety towards antibacterial activity. Synthetic methods adopted for making compounds **1**–**22** are illustrated in Schemes 1–3. Synthesis of s-triazine (cyanuric acid) derivatives **1**–**5** was performed by means of nucleophilic displacement of chlorine atoms of cyanuric chloride (**23**). According to this method compounds **1**–**5** were obtained by treating two equivalents of benzyl alcohol derivatives (**24**–**28**) with cyanu-



Scheme 1.

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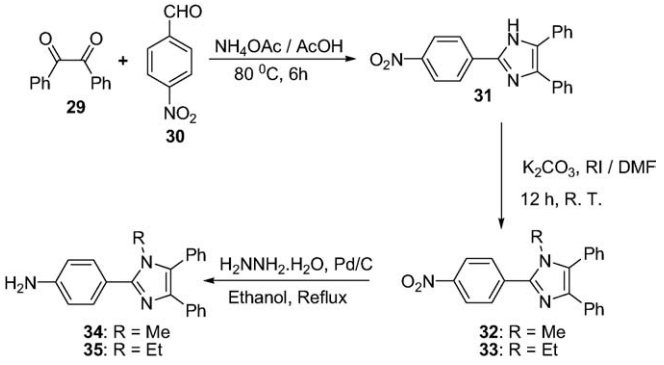
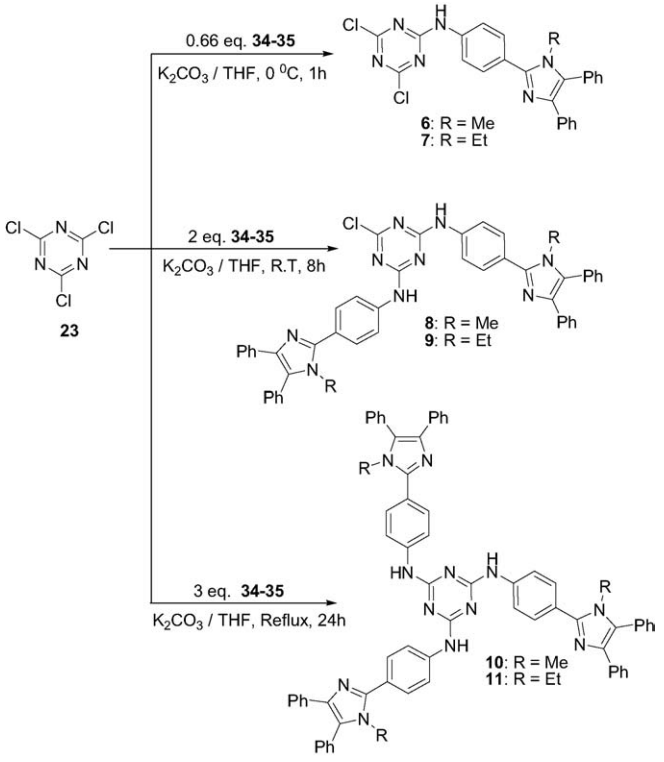


Scheme 2.



Scheme 3.

ric chloride in the presence of base (Scheme 1). Another new series of compounds **6**–**11** were synthesized (Scheme 2) in multiple steps via intermediates **34**–**35**, which were obtained by a procedure starting with the condensation of benzil (**29**) with *p*-nitrobenzaldehyde (**30**) to afford **31** [28]. *N*-alkylation of **31** with alkyl iodide in the presence of base gave **32**–**33**. Further reduction of nitro group of **32**–**33** with Pd/C and hydrazine hydrate yielded **34**–**35** [29]. Treatment of cyanuric chloride (**23**) with variable amounts of **34**–**35** in the presence of base gave **6**–**11**. Compounds **12**–**14** were synthesized (Scheme 3) by allowing reaction between different molar ratios of cyanuric chloride (**23**) and R-(+)-α-methyl benzylamine (**36**) in the presence of K_2CO_3 and 18-Crown-6 [30,31]. Compounds **15**–**22** were prepared as per the reported procedure [32]. All the synthesized compounds were purified by column chromatography followed by recrystallization and characterized by spectroscopic data as NMR, mass, IR and elemental analysis.

3. Pharmacology

3.1. Antibacterial activity

The in vitro antibacterial screening of all the compounds were evaluated against selected (Table 1) Gram-positive organisms viz. *Bacillus subtilis* (MTCC 441), *Bacillus sphaericus* (MTCC 11) *Staphylococcus aureus* (MTCC 96) and three Gram-negative organisms viz. *Chromobacterium violaceum* (MTCC 2656), *Klebseilla aerogenes* (MTCC 39) and *Pseudomonas aeruginosa* (MTCC 741) by broth dilution method recommended by National Committee for Clinical Laboratory (NCCL) standards [33].

4. Results and discussion

The minimum inhibitory concentration (MIC) was determined for each compound along with streptomycin as standard control and the results are presented in Table 1. The MIC values of four series of *s*-triazine derivatives (Fig. 1 and Table 1) against tested organisms displayed significant activity with a degree of variation. It is found that compounds **5** and **21** displayed substantial activity against *B. subtilis* and remaining compounds are significantly active. *s*-Triazines **2**, **6**, **9**, **10**, **18** and **22** are equipotent against *B. sphaericus* compared to reference compound. Rest of the compounds have exhibited significant to substantial activity against the same strain. Substantial activity is achieved in case of compounds **4**, **18**, **21** and **22** against *S. aureus* and the remaining compounds are significantly active against the same species. All the *s*-triazine derivatives have exhibited significant to moderate activity against Gram-negative bacteria. Derivatives **7**, **10**, **15**, **17** and **22** have exhibited substantial activity against *C. violaceum.* Decreased activity is observed in case of *K. aerogenes* with all the *s*-triazines. It is obvious from the structure-activity profile of substituted *s*-triazines; a small structural variation may induce an effect on antibacterial activity. By observing the antibacterial activities of all the derivatives, it is interesting to note that the dibenzyloxy *s*-triazine derivatives **1**–**5** have shown substantial antibacterial activity against *B. sphaericus* and moderately active against all the remaining strains. 4-Chlorobenzyloxy triazine, **5** exhibited significant activity against *B. subtilis* and moderately active against *B. sphaericus*. Slight decreased activity was observed by substituting the chlorine with fluorine group in compound **4**, except methyl derivative **2** in this series has shown comparable activity against *B. sphaericus*. Further diminished activity is demonstrated in compounds **1** and **3**, by replacing the fluorine with hydrogen and methoxy groups, respectively. Imidazole substituted *s*-triazines **6**, **9** and **10** were equipotent against *B. sphaericus* and moderately active against *C. violaceum*. Remaining *s*-triazine derivatives in this series, compounds **7**, **8** and **11** displayed least activity against all the tested organisms. Decreased antibacterial activity was

Table 1
In vitro antibacterial activity of substituted *s*-triazines (**1**–**22**)

Compound number	MIC, μg ml^{-1}					
	Gram-positive organism			Gram-negative organism		
	B. subtilis	*B. sphaericus*	*S. aureus*	*C. violaceum*	*K. aerogenes*	*P. aeruginosa*
1	25	25	25	25	50	> 250
2	25	12.5	25	25	50	> 250
3	50	25	50	50	25	> 250
4	25	50	12.5	25	12.5	> 250
5	12.5	50	25	25	12.5	> 250
6	25	12.5	25	25	50	> 250
7	25	25	25	25	25	> 250
8	50	25	25	12.5	50	> 250
9	25	12.5	50	25	50	> 250
10	25	12.5	50	12.5	25	> 250
11	50	25	50	25	50	> 250
12	50	50	25	25	50	> 250
13	50	50	25	25	50	> 250
14	25	25	25	50	25	> 250
15	25	25	25	12.5	25	> 250
16	25	25	25	25	25	> 250
17	25	25	25	12.5	25	> 250
18	50	12.5	12.5	50	12.5	> 250
19	25	25	50	25	25	> 250
20	25	25	50	50	25	> 250
21	12.5	25	12.5	25	25	> 250
22	25	12.5	12.5	12.5	50	> 250
Streptomycin	6.25	12.5	6.25	3.125	1.562	3.125

• Negative control (acetone).

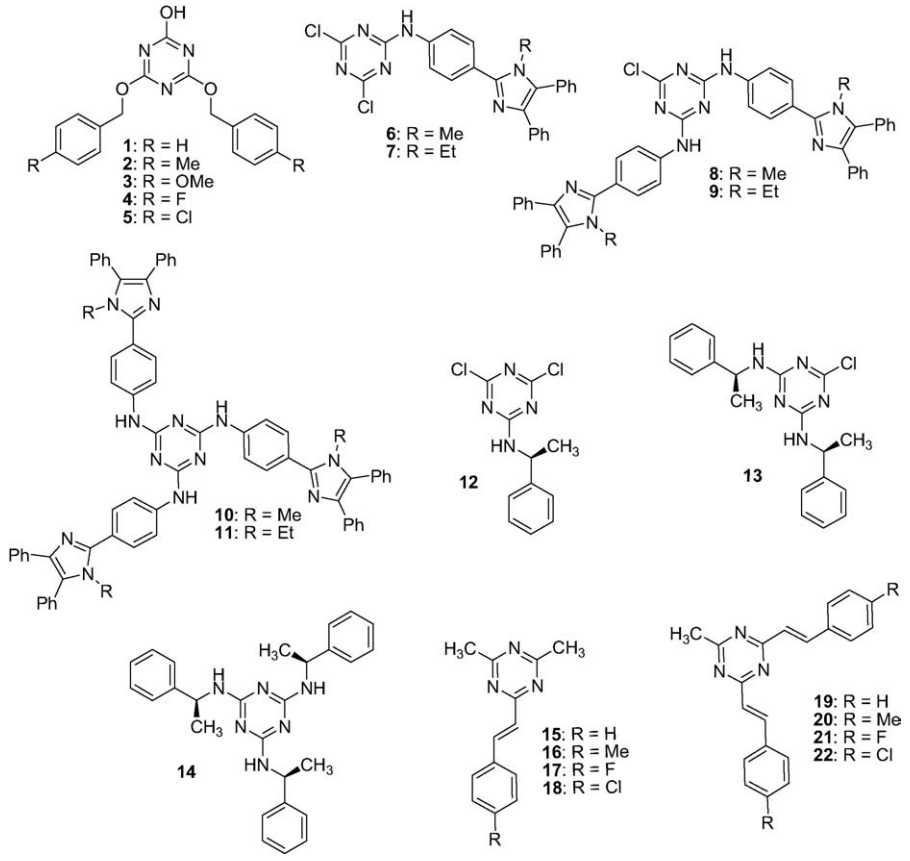


Fig. 1.

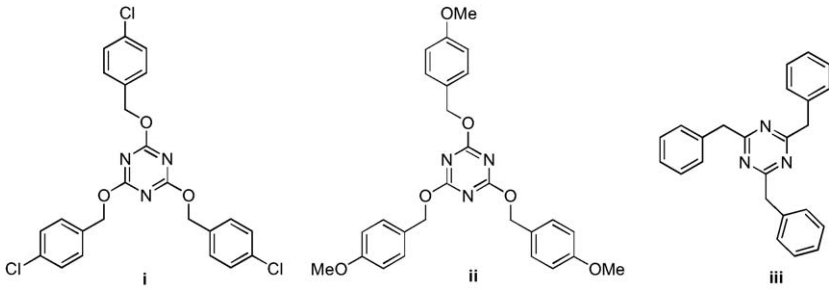


Fig. 2.

encountered for compounds **12–14** where chlorines were replaced in cyanuric chloride with 1-phenyl ethylamino group, respectively. Compounds **15**–**22** exerted significant antibacterial activity against tested Gram-positive and moderate activity against Gram-negative bacterial strains. Compounds with chloro substitution at *para* position, **18** and **22** exhibited equivalent activity with the standard drug streptomycin against *B. sphaericus* and significantly active against *S. aereus* and moderately active against the remaining tested organisms. In case of fluoro derivatives, **17** and **21**, decrease in the antibacterial activity was observed compared to chloro derivatives. Rest of the compounds in this series (**15**, **16**, **19** and **20**) displayed moderate activity.

Moreover, by changing the substitution pattern in *s*-triazine derivatives may influence the antibacterial activity. The most active trisubstituted *s*-triazines derivatives (**i–iii**) previously reported by us [19] are given in Fig. 2. The di-substituted benzyloxy *s*-triazine derivatives exhibited a slightly lower antibacterial activity than the tri-substituted benzyloxy *s*-triazines (Fig. 2) [19]. Most of the imidazole containing compounds display biological activities, probably due to their involvement in catalytic processes at the active sites of enzymes due its pK_a [34,35]. In this context, we introduced the imidazole group in to the triazine moiety (**6–11**) but mono-, di- and tri-substituted imidazoloaniline containing *s*-triazine derivatives (**6–11**) display moderate activity. Therefore imidazole group is not influencing the antibacterial activity of s-triazine derivatives (**6–11**). Introduction of methyl group in benzylamine and by changing the substitution pattern from mono to di- and tri-substituted chiral benzylamine containing *s*-triazine derivatives (**12–14**) displayed moderate antibacterial activity and comparable with the previously reported benzylamine containing *s*-triazine derivatives. In overall, trisubstituted *s*-triazines are more active than the mono and disubstituted *s*-triazines. All *s*-triazine derivatives in this communication are inactive towards *P. aeruginosa* at the maximum concentration of 250 μg ml^{-1}. We observed that all the 22 compounds did not display any antifungal activity.

5. Conclusion

In conclusion, four series of substituted *s*-triazines were synthesized and evaluated for antibacterial activity. Most of the compounds exhibited moderate to significant in vitro antibacterial activity. Among them, compounds **2**, **6**, **9**, **10**, **18** and **22** showed significant activities against tested Gram-positive organisms and comparable activity towards *B. sphaericus* with respect to streptomycin as standard. Derivatives with chloro substitution in styryl *s*-triazines **18** and **22** demonstrated comparable and significant activity against *B. sphaericus* and *S. aureus.* In overall, trisubstituted *s*-triazines are more active than the mono and disubstituted *s*-triazines.

6. Experimental protocols

All the reagents were A.R. grade and used without further purification. Melting points were determined on a Thomas Hoover melting point apparatus and are uncorrected. ^{1}H NMR spectra were recorded on Gemini (200 MHz) spectrometer and ^{13}C NMR spectra on Bruker Avance (75 MHz) spectrometer in $CDCl_3$ and/or DMSO-d_6 using TMS as internal standard. Mass spectra were obtained on VG-AUTOSPEC spectrometer. IR spectra were taken on a SHIMADZU 435 infrared spectrophotometer. Elemental analysis were performed using a Vario-EL elemental analyzer.

6.1. Synthesis of 2,4-bis (benzyloxy)-6-(5H)-one-1,3,5-triazine (1)

Benzyl alcohol (**24**, 2.16 g, 20 mmol) in 20 ml THF was added drop-wise to an aqueous solution of 5% NaOH (10 ml) at 0–5 °C. The temperature was allowed to increase 25 °C and kept for reflux for 1 h. Cyanuric chloride (**23**, 1.83 g, 10 mmol) in THF was added at 10 °C and after reflux for 10 h, removed the solvent and extracted with ethyl acetate. Recrystallization from ethanol afforded **1** as colorless solid (2.16 g., 70%). m.p. 152 °C; ^{1}H NMR ($CDCl_3$): δ 1.4 (b, 1H); 5.47 (s, 4H); 7.45 (m, 10H); ^{13}C NMR ($CDCl_3$): δ 160, 134.3, 128.7, 128.6, 70.7; MS (FAB): 310 (M + 1); IR (KBr): 3405, 3032, 2795, 1677, 1639, 1491 cm^{-1}; Calc. for $C_{17}H_{15}N_3O_3$: C, 66.01; H, 4.89; N, 13.58%. Found: C, 65.97; H, 4.82; N, 13.55%.

6.2. 2,4-Bis (4-methyl benzyloxy)-6-(5H)-one-1,3,5-triazine (2)

Similar procedure as for **1** led to **2** (2.19 g., 65%). m.p. 138–140 °C; ^{1}H NMR ($CDCl_3$): δ 1.9 (b, 1H); 2.3 (s, 6H); 5.35 (s, 4H); 7.1 (d, $J = 8.9$ Hz, 4H); 7.40 (d, $J = 8.6$ Hz, 4H); MS (FAB): 338 (M + 1); IR (KBr): 3413, 3025, 2765, 1664, 1642, 1510 cm^{-1}; Calc. for $C_{19}H_{19}N_3O_3$: C, 67.64; H, 5.68; N, 12.46%. Found: C, 67.58; H, 5.61; N, 12.33%.

*6.3. 2,4-Bis (4-methoxy benzyloxy)-6-(5H)-one-1,3,5-triazine (**3**)*

Similar procedure as for **1** led to **3** (2.28 g., 62%). m.p. 145 °C; ^{1}H NMR ($CDCl_3$): δ 1.2 (b, 1H); 3.8 (s, 6H); 5.0 (s, 4H); 6.85 (d, J = 8.5 Hz, 4H); 7.4 (d, J = 8.1 Hz, 4H); MS (FAB): 370 (M + 1); IR (KBr): 3402, 3039, 2778, 1672, 1625, 1502 cm^{-1}; Calc. for $C_{19}H_{19}N_3O_5$: C, 61.78; H, 5.18; N, 11.38%. Found: C, 61.71; H, 5.14; N, 11.33%.

*6.4. 2,4-Bis (4-fluorobenzyloxy)-6-(5H)-one-1,3,5-triazine (**4**)*

Similar procedure as for **1** led to **4** (2.35 g., 68%). m.p. 162–164 °C; ^{1}H NMR ($CDCl_3$): δ 2.3 (b, 1H); 5.55 (s, 4H); 7.25 (d, J = 9.0 Hz, 4H); 7.6 (d, J = 9.2 Hz, 4H); MS (FAB): 346 (M + 1); IR (KBr): 3432, 3012, 2759, 1666, 1621, 1507 cm^{-1}; Calc. for $C_{17}H_{13}F_2N_3O_3$: C, 59.13; H, 3.79; N, 12.17%. Found: C, 59.06; H, 3.65; N, 12.09%.

*6.5. 2,4-Bis (4-chlorobenzyloxy)-6-(5H)-one-1,3,5-triazine (**5**)*

Similar procedure as for **1** led to **5** (2.26 g., 60%). m.p. 168–169 °C; ^{1}H NMR ($CDCl_3$): δ 2.4 (b, 1H); 5.5 (s, 4H); 7.35 (d, J = 7.9 Hz, 4H); 7.55 (d, J = 8.5 Hz, 4H); MS (FAB): 378 (M + 1); IR (KBr): 3413, 3033, 2787, 1663, 1630, 1513 cm^{-1}; Calc. for $C_{17}H_{13}Cl_2N_3O_3$: C, 53.99; H, 3.46; N, 11.11%. Found: C, 53.88; H, 3.38; N, 11.02%.

*6.6. 2-(4-Nitro-phenyl)-4,5-diphenyl-1H-imidazole (**31**)*

A mixture of benzil **29** (2.1 g, 10 mmol), ammonium acetate (7.7 g, 0.1 mol) in glacial acetic acid (30 ml) was stirred at 80 °C for 1 h under nitrogen atmosphere. *p*-Nitro benzaldehyde **30** (1.51 g, 10 mmol) in glacial acetic acid (10 ml) was added drop-wise over a period of 15 min at the same temperature and stirred for another 4 h. The resulting homogeneous solution was poured over crushed ice (200 g). The yellow precipitate was collected by filtration and washed with cold water, then dried under vacuum. The crude product was recrystallized from ethyl acetate thrice to afford the pure **31** (2.73 g, 80%). m.p. 210 °C; ^{1}H NMR ($CDCl_3$): δ 7.2 (m, 4H); 7.45 (m, 6H); 8.0 (d, J = 8 Hz, 2H); 8.2 (b, NH); 8.35 (d, J = 8.2 Hz, 2H); MS (FAB): 342 (M + 1); IR (KBr): 3391, 1596, 1514, 1446 cm^{-1}; Calc. for $C_{21}H_{15}N_3O_2$: C, 73.89; H, 4.43; N, 12.31%. Found: C, 73.86; H, 4.41; N, 12.27%.

*6.7. 1-Methyl-2-(4-nitro-phenyl)-4,5-diphenyl-1H-imidazole (**32**)*

K_2CO_3 (0.97 g, 7 mmol) was added to a solution of **31** (2 g, 5.8 mmol) in DMF (25 ml) at 0 °C under nitrogen. After 15 min, methyl iodide (0.85 g, 6 mmol) wad added in one portion at 0 °C and continued stirring for 2 h. Then the mixture was stirred overnight at room temperature and poured over crushed ice (150 g). Filtered the reaction mixture, washed with ice cold water for several times to remove DMF and dried in oven. Purified the product by column chromatography using ethyl acetate/hexane (1:20 v/v) as eluent. (1.96 g, 95%). m.p. 198 °C; ^{1}H NMR ($CDCl_3$): δ 3.6 (s, 3H); 7.2 (m, 4H); 7.45 (m, 6H); 8.0 (d, J = 8 Hz, 2H); 8.35 (d, J = 8.2 Hz, 2H); MS (FAB): 356 (M + 1); IR (KBr): 3064, 2924, 1592, 1507 cm^{-1}; Calc. for $C_{22}H_{17}N_3O_2$: C, 74.35; H, 4.82; N, 11.82%; Found: C, 74.32; H, 4.80; N, 11.79%.

*6.8. 1-Ethyl-2-(4-nitro-phenyl)-4,5-diphenyl-1H-imidazole (**33**)*

Above procedure was adopted except ethyl iodide was used instead of methyl iodide to synthesize **33** (1.99 g, 93%). m.p. 192 °C; ^{1}H NMR ($CDCl_3$): δ 1.1 (t, 3H); 4.0 (q, 2H); 7.1–7.2 (m, 4H); 7.4–7.6 (m, 6H); 7.95 (d, J = 7 Hz, 2H); 8.35 (d, J = 7 Hz, 2H); MS (FAB): 370 (M + 1); IR (KBr): 3060, 2972, 1592, 1508 cm^{-1}; Calc. for $C_{23}H_{19}N_3O_2$: C, 74.78; H, 5.18; N, 11.37%. Found: C, 74.75; H, 5.16; N, 11.34%.

*6.9. 4-(1-Methyl-4,5-diphenyl-1H-imidazol-2-yl)-phenylamine (**34**)*

Palladium–carbon catalyst (10%) was added portion-wise during 5–10 min to a hot solution of **32** (1 g, 2.8 mmol) in ethanol (100 ml) containing hydrazine hydrate (0.7 g, 14 mmol). The mixture was heated under reflux for 1 h. The hot solution was filtered through a Whatman paper to remove Pd and further filtrate was filtered through silica gel (5 g) and the solvent was evaporated. Pure product was obtained and used without further purification (0.9 g, 97%). m.p. 204 °C; ^{1}H NMR ($CDCl_3$): δ 3.55 (s, 3H); 4.6 (b, 2H); 6.75 (d, J = 8.1 Hz, 2H); 7.15–7.25 (m, 4H); 7.45–7.55 (m, 8H); MS (FAB): 326 (M + 1); IR (KBr): 3428, 3206, 2925, 1613, 1470 cm^{-1}; Calc. for $C_{22}H_{19}N_3$: C, 81.20; H, 5.89; N, 12.91%. Found: C, 81.18; H, 5.87; N, 12.87%.

*6.10. 4-(1-Ethyl-4,5-diphenyl-1H-imidazol-2-yl)-phenylamine (**35**)*

It is synthesized according to above procedure (0.94 g, 97%). m.p. 182 °C; ^{1}H NMR ($CDCl_3$): δ 1.1 (t, 3H); 3.95 (q, 2H); 6.7–6.75 (d, J = 6 Hz, 2H); 7.2–7.3 (m, 4H); 7.45–7.55 (m, 8H); MS (FAB): 340 (M + 1); IR (KBr): 3423, 3312, 3199, 2928, 1609, 1538 cm^{-1}; Calc. for $C_{23}H_{21}N_3$: C, 81.38; H, 6.24; N, 12.38%. Found: C, 81.35; H, 6.22; N, 12.34%.

*6.11. 4,6-Dichloro-[1,3,5]triazin-2-yl)-[4-(1-methyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-amine (**6**)*

To a solution of **34** (0.65 g, 2 mmol) in THF (25 ml), K_2CO_3 (0.28 g, 2 mmol) was added at 0 °C under nitrogen and stirred for 30 min. Cyanuric chloride **23** (0.55 g, 3 mmol) in THF (10 ml) was added drop-wise over a period of 15 min. After stirring for another 2 h, solvent was evaporated and purified by column chromatography using ethyl acetate/hexane (1:5 v/v) as a eluent to afford the product (0.8 g, 85%). m.p. 165 °C; ^{1}H NMR (DMSO-d_6): δ 3.5 (s, 3H); 7.1 (m, 2H); 7.4 (m, 4H); 7.8(m, 8H); 11.3 (b, 1H); MS (FAB):

473 (M + 1); IR (KBr): 3421, 3225, 3054, 2926, 1606, 1556 cm^{-1}; Calc. for $C_{25}H_{18}Cl_2N_6$: C, 63.43; H, 3.83; N, 17.75%. Found: C, 63.4; H, 3.81; N, 17.72%.

6.12. (4,6-Dichloro-[1,3,5]triazin-2-yl)-[4-(1-ethyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-amine (7)

Above procedure was adopted except **35** is used instead of **34** to synthesize **7** (0.82 g, 65%). m.p. 158 °C; ^{1}H NMR (DMSO-d_6): δ 1.2 (t, 3H); 3.9 (q, 2H); 7.1 (m, 2H); 7.4 (m, 4H); 7.8(m, 8H); 11.3 (b, 1H); ^{13}C NMR (DMSO-d_6): δ 156.0, 154.0, 150.5, 144.5, 142.0, 132.0, 131.7, 131.5, 131.3, 131.0, 130.2, 130.0, 129.8, 129.0, 128.0, 127.0, 126.5, 121.0, 118.0, 41.5, 14.5; MS (ESI): 487 (M + 1); IR (KBr): 3435, 3228, 3057, 2928, 1609, 1557 cm^{-1}; Calc. for $C_{26}H_{20}Cl_2N_6$: C, 64.07; H, 4.14; N, 17.24%. Found: C, 64.05; H, 4.11; N, 17.22%.

6.13. 6-Chloro-N,N′-bis-[4-(1-methyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-[1,3,5] triazine-2,4-diamine (8)

To a solution of **34** (0.65 g, 2 mmol) in THF (25 ml), K_2CO_3 (0.28 g, 2 mmol) was added at 0 °C under nitrogen and stirred for 30 min. Cyanuric chloride **23** (0.18 g, 1 mmol) in THF (10 ml) was added drop-wise over a period of 15 min and stirred for overnight. Then the solvent was evaporated and purified by column chromatography using ethyl acetate/hexane (2:3 v/v) as eluent to afford the product (0.49 g, 55%). m.p. 212 °C; ^{1}H NMR (DMSO-d_6): δ 3.45 (s, 6H); 7.15 (m, 4H); 7.4 (m, 8H); 7.85 (m, 16H); 11.1 (b, 2H); MS (FAB): 762 (M + 1); IR (KBr): 3390, 3284, 3054, 2924, 1594, 1570 cm^{-1}; Calc. for $C_{47}H_{36}ClN_9$: C, 74.05; H, 4.76; N, 16.54%. Found: C, 74.02; H, 4.74; N, 16.51%.

6.14. 6-Chloro-N,N′-bis-[4-(1-ethyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-[1,3,5] triazine-2,4-diamine (9)

Above procedure was adopted except **35** is used instead of **34** to synthesize **9** (0.5 g, 50%). m.p. 223 °C; ^{1}H NMR (DMSO-d_6): δ 1.3 (t, 6H); 3.95 (q, 4H); 7.15 (m, 4H); 7.4 (m, 8H); 7.9 (m, 16H); 11.5 (b, 2H); ^{13}C NMR (DMSO-d_6): δ 154.3, 152.6, 143.9, 143.5, 140.9, 135.3, 130.9, 130.6, 130.4, 130.2, 129.9, 129.3, 129.0, 128.5, 127.6, 127.4, 126.4, 126.2, 120.0, 119.5, 117.0, 41.0, 14.0; MS (FAB): 790 (M + 1); IR (KBr): 3398, 3285, 3054, 2924, 1599, 1578 cm^{-1}; Calc. for $C_{49}H_{40}ClN_9$: C, 74.46; H, 5.10; N, 15.95%. Found: C, 74.43; H, 5.07; N, 15.92%.

6.15. N,N′,N″-Tris-[4-(1-methyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-[1,3,5]triazine-2,4,6-triamine (10)

To a solution of **34** (0.98 g, 3 mmol) in THF (30 ml), K_2CO_3 (0.42 g, 3 mmol) was added at 0 °C under nitrogen and stirred for 30 min. Cyanuric chloride **23** (0.18 g, 1 mmol) in THF (10 ml) was added drop-wise over a period of 15 min and kept for reflux for 24 h. Then the solvent was evaporated and purified by column chromatography using methanol/ethyl acetate (1:20 v/v) as eluent to afford the product (0.57 g, 55%). m.p. 251 °C; ^{1}H NMR (DMSO-d_6): δ 3.4 (s, 9H); 7.1 (m, 6H); 7.5 (m, 12H); 7.9 (m, 24H); 11.2 (b, 3H); ^{13}C NMR ($CDCl_3$ + DMSO-d_6): δ 163.5, 144.3, 142.8, 135.4, 131.4, 130.7, 130.3, 129.8, 129.4, 128.6, 128.3, 128.1, 127.4, 127, 126.8, 120.5, 41.1; MS (ESI): 1052 (M + 1); IR (KBr): 3427, 3025, 1649, 1553 cm^{-1}; Calc. for $C_{69}H_{54}N_{12}$: C, 78.83; H, 5.18; N, 15.99%. Found: C, 78.8; H, 5.14; N, 15.96%.

6.16. N,N′,N″-Tris-[4-(1-ethyl-4,5-diphenyl-1H-imidazol-2-yl)-phenyl]-[1,3,5]triazine-2,4,6-triamine (11)

Above procedure was adopted except **35** is used instead of **34** to synthesize **11** (0.55 g, 50%). m.p. 238 °C; ^{1}H NMR (DMSO-d_6): δ 1.2 (t, 9H); 3.85 (q, 6H); 7.15 (m, 6H); 7.4 (m, 12H); 7.8 (m, 24H); 11.5 (b, 3H); ^{13}C NMR ($CDCl_3$ + DMSO-d_6): δ 164, 144.5, 142.9, 135.4, 131.4, 130.9, 130.3, 129.8, 129.4, 128.6, 128.3, 128.1, 127.4, 127, 126.8, 120, 40.1, 14.8; MS (FAB): 1093 (M + 1); IR (KBr): 3432, 3052, 1642, 1555, 1527 cm^{-1}; Calc. for $C_{72}H_{60}N_{12}$: C, 79.10; H, 5.53; N, 15.37%. Found: C, 79.08; H, 5.51; N, 15.33%.

Compounds **12**–**14** were synthesized according to the reported procedure and characterization data for **12** and **14** can be found in literature [30,31].

6.17. 6-Chloro-bis [(R)-1-methyl benzylamino]-1,3,5-triazine (13)

This compound (**13**) was synthesized according to the reported procedure (2.12 g., 10 mmol, 60%) [16b]. m.p. 73 °C; ^{1}H NMR ($CDCl_3$): δ 1.3 (m, 6H); 2.3 (b, 2H); 4.95 (m, 2H); 7.25 (m, 10H); MS (FAB): 354 (M + 1); IR (KBr): 3464 cm^{-1}; Calc. for $C_{19}H_{20}ClN_5$: C, 64.49; H, 5.70; N, 19.79%; Found: C, 64.38; H, 5.61; N, 19.70%.

Compounds **15**–**22** were synthesized according to the reported procedure and characterization data can be found in literature [32].

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