Indian Journal of Chemistry
Vol. 63, July 2024, pp. 664-672
DOI: 10.56042/ijc.v63i7.7336

Visible light mediated eosin-Y catalysed direct synthesis of biologically potent of [1,2,4]triazolo [3,4-*b*] [1,3,4] thiadiazols

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Received 15 December 2023; accepted (revised) 26 June 2024

A green light promoted, facile, one-pot approach for the synthesis of biologically important 6-(substituted/unsubstituted benzylthio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole **6a-m** has been developed. New synthetic approach for the preparation of tailor-made synthesis of triazolo [3,4-b] [1,3,4] thiadiazol derivatives **6a-m** are in extremely high demand as they display significant potent activity against fungal strains as well as on mutant strains. Herein, we have designed an efficient, cheap and easy photo-induced synthetic strategy to obtain the target compound with excellent yield. Compounds **6a-m** have been evaluated *in vitro* for their fungitoxicities against *Penicillium citrinum* and *Fusarium oxysporum*. All the synthesized compounds have been found to be antifungal active. Among them, activities of some of the compounds displayed are comparable with that of the commercial fungicide griseofulvin and Dithane M-45. Structure activity relationships (SAR) for the screened compounds have been discussed.

Keywords: 1,2,4-Triazoles, [3,4-b][1,3,4] Thiadiazols, Fused heterocyclic, Fungicidal activity, Photoredox catalysis, Reduced-risk fungicides

Literature survey reveals that design, synthesis and production of organic compounds having pharmaceutical value remain one of the main objectives of organic and medicinal chemistry. The chemistry of 1,2,4-triazoles and their fused heterocyclic derivatives have received considerable attention due to their effective medicinal importance. Large number of marked drugs, such as triazolam, alprazolam, ribavirin, anatrozole and etizolam, containing the s-triazole group[1-6]. In Past decade, compounds carrying the s-triazole moiety possess a wide spectrum of chemotherapeutic activities including antifungal[7,8], antiviral[9], anthelmintic[10], antibacterial[11], antitumor[12-14], anti-inflammatory[15-17], antitubercular[18], analgesic[19,20], antipyretic[21,22], and anticancer activities[23]. Indeed, some of derivatives were actually active constituents of drugs[24] (Fig. 1).

Among the different azole heterocycles 1,3,4-thiadiazole nucleus have aroused much attention due to their diversified biological activities, such as antifungal[25] anti-viral[26,27], anti-microbial[28-31], anti-tuberculosis[32,33], anti-convulsant[34-36], anti-cancer[37-39], anti-ulcer[40,41], anti-inflammatory and analgesic[42-44], anti-depressant[45,46], diuretic[47], anti-diabetic[48,49], anti-malarial, anti-leishmanicidal[50,51], anti-hyperlipidemia[52,53], antioxidant, anti-influenza[54,55], anti-hypolipidemic, anti-hypertensive[56], *etc*. Well-known clinically used drugs containing 1,3,4-thiadiazole nucleus (Fig. 2) such as Cefazolin and Cefazedone (antibiotics, cell wall synthesis inhibitors), Acetazolamide and Methazolamide (Diuretics, carbonic anhydrase inhibitors), Megazol (Antiprotozoal, protein and DNA synthesis inhibitor) are commercially available in the market[57]. It was reported that the thiadiazole group could act as the bio-isosteric substitute of the thiazole moiety[58]. The biological activity of thiadiazole derivatives is due to their strong aromaticity. For higher vertebrates including humans, thiadiazole showed little or no toxicity effect[59]. Therefore, the 1,3,4-thiadiazole scaffold has become the centre of attraction for researchers to know the molecular mechanisms involved for its various therapeutic actions against various diseases. Today a major worldwide problem is resistance towards the available drug therefore in order to deal with resistance, need to design and synthesise new and more effective compounds has become one of the most important areas of research today.

Recent years have witnessed a phenomenal growth in application of Visible light mediated photoredox

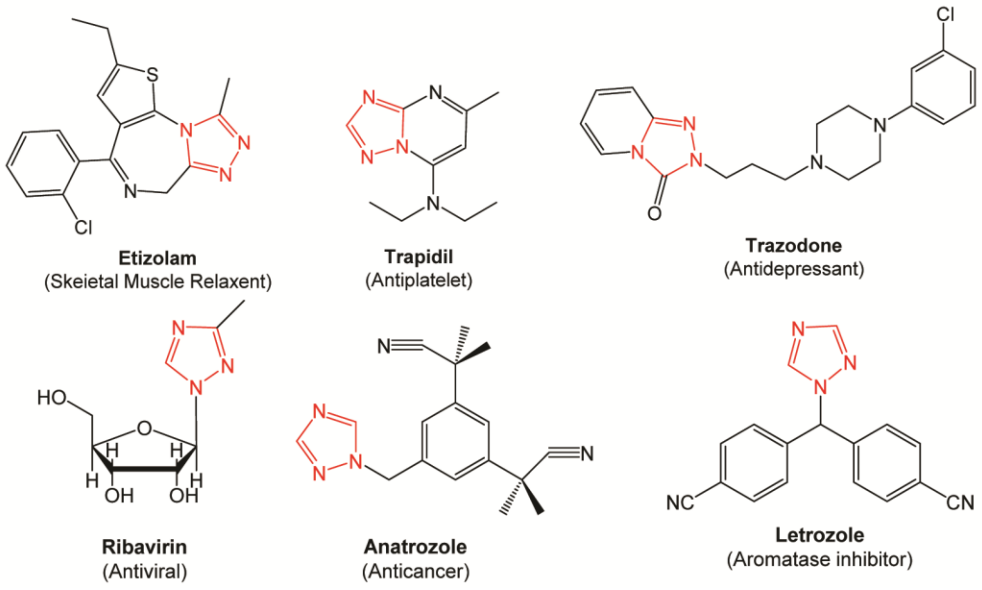


Fig. 1 — Clinically used Drugs having 1,2,4-triazole nucleus

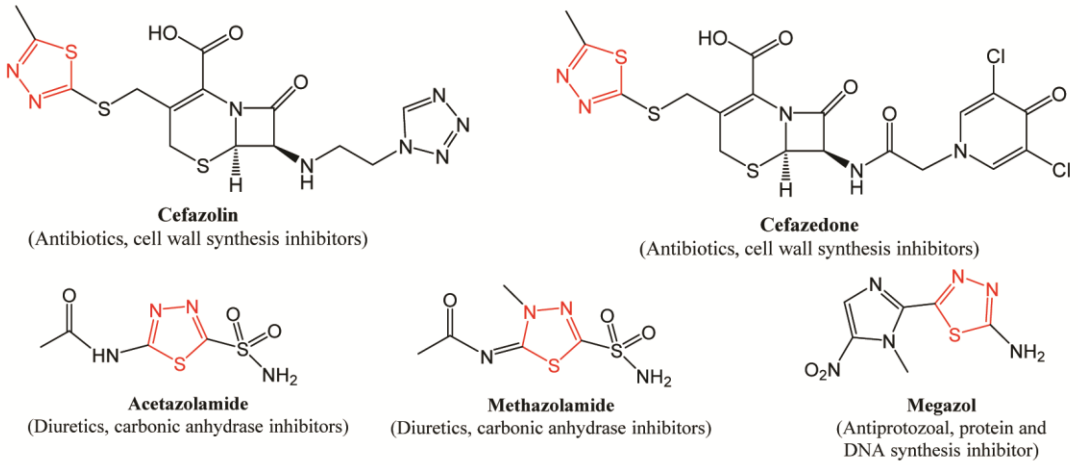


Fig. 2 — Clinically used Drugs having 1,3,4 thiadiazole nucleus

catalysis for organic synthesis under solvent-free conditions and in continuation of our research work[60-68] are gaining much attention because of the mild reaction conditions, short reaction times, operational simplicity, formation of cleaner products and special catalytic attributes under heterogeneous reaction conditions. Photo-induced catalysis is conceivably one of the most exponentially growing areas of economical synthetic organic chemistry. Visible light photocatalysis has evolved into a widely used method in organic syntheses as it is the most sustainable reaction inducer and has been increasingly used as a powerful strategy to promote numerous synthetic transformations in organic chemistry as it is a safe, renewable, and inexpensive source of chemical energy

Although enabling the synthesis of an incredibly wide opportunity of molecules presenting exceptional complexity, organic synthesis generally suffers from the large amounts of toxic waste that are produced during syntheses[69]. Defining green metrics to evaluate the environmental impact of chemical processes has clearly revealed solvents as major contributors to the production of undesirable waste[70]. Yet, performing organic synthesis with less or no solvent in conventional batch reactors generally lead to material diffusion limitations. In order to solve these problems, some organic chemists have turned to use of solid-state synthesis. isolation of products in high yields, reduction of the environmental impact and discovering unexpected selectivities[71,72].

Among the wide number of organic reactions that could benefit from innovative approach, reagents, 1,1′-Thiocarbonyldiimidazole (TCDI) has been used for various applications in organic synthesis showing precise efficiency while generating noticeable interest. Some of them has emerged as the most versatile and effective reagent and are now used an industrial scale in the synthesis of high value compounds such as agrochemicals, pharmaceuticals and fine chemicals.

Experimental Section

All materials used were purchased from Sigma-Aldrich and used without any additional purification. Melting points were determined by open glass capillary method and are uncorrected. All chemicals used were reagent grade and were used as received. The structure of synthesized compounds **6a**–**m** was confirmed by using ^{1}H and ^{13}C NMR spectra in DMSO-d_6 using TMS as an internal reference (chemical shift in δ, ppm).

General procedure for the preparation of products, 6a-m

The reactions were carried out in a 10mL glass vial, equipped with a rubber septum and a magnetic stirrer. solution of substituted 4-amino-4*H*-[1,2,4]triazole-3-thiol **1** (1.5 mmol), 1,1′-Thiocarbonyldiimidazole (TCDI) **2** (1.5 mmol) in toluene (3 mL) was added with eosin Y (2 mol%) and the mixture was irradiated with 18W green-LED under an air atmosphere at RT. Benzyl halide **5a-m** (1.5 mmol) were added in the crude mixture of product. The mixture was irradiated with 18W green-LED under an air atmosphere at RT for 2-3 hrs. Completion of the reaction were monitored by TLC silica gel. The reaction mixture were placed into a separatory funnel, water (5 mL) was added and the mixture was extracted with EtOAc (3-5 mL). The organic layer was separated, and the aqueous layer was extracted with ethyl acetate (2-15 mL). The combined organic extract was dried over anhydrous $MgSO_4$, filtered and evaporated under reduced pressure. Finally, the products (**6a-m**) were isolated by column chromatography silica gel by using Hexanes:Ethyl Acetate (8:2 v/v) as eluent.

6-(Benzylthio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6a

Brown solid. Yield 90%. m.p. 218°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.16 (d, *J* = 7.50 Hz, 2H, H2, H6), 7.65–7.47 (m, 5H, H Ar), 7.41–7.25 (m, 3H, H3,, H4, H5), 4.65 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 168.36, 157.68, 146.49, 143.04, 139.25, 137.48, 135.29, 134.41, 132.06, 131.25, 130.90, 129.26, 128.93, 128.78, 128.59, 128.43, 127.56, 127.43, 127.19, 126.62, 125.23, 122.92121.36, 115.09, 36.73.

6-((4-Bromobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6b

Brown solid. Yield 91%. m.p. 213°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.12 (d, *J* = 6.50 Hz, 2H, H2, H6), 7.64–7.50 (m, 5H, H Ar), 7.45 (d, *J* = 8.20 Hz, 2H, H3, H5), 4.61 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 137.09, 132.94, 132.75, 131.79, 130.57, 127.25, 126.74, 122.43, 38.25.

6-((4-Chlorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6c

Brown solid. Yield 94%. m.p. 219°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.13 (d, *J* = 7.30 Hz, 2H, H2, H6), 7.64–7.47 (m, 5H, H Ar), 7.41 (d, *J* = 5.90 Hz, 2H, H3, H5), 4.63 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 136.67, 132.45, 131.80, 130.58, 130.02, 127.26, 126.75, 38,21.

6-((4-Fluorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6d

Brown solid. Yield 89%. m.p. 200°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.15 (d, *J* = 7.30 Hz, 2H, H2, H6), 7.65–7.46 (m, 5H, H Ar), 7.17 (t, *J* = 8.5 Hz, 2H, H3,, H5), 4.64 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 133.72, 132.78, 132.65, 131.79, 130.59, 127.27, 126.79, 117.08, 116.74, 38.20.

6-((4-Nitrobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6e

Yellow solid. Yield 90%. m.p. 221°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.20 (d, J = 6.3 Hz, 2H, H2, H6), 8.10 (d, J = 8.3 Hz, 2H, H2, H6), 7.79 (d, J = 8.7 Hz, 2H, H3, H5), 7.57 (m, 3H, HAr). 4.78 (s, 2H, CH_2); 1^{13}C NMR (62 MHz, DMSO-d_6): δ 131.80, 130.56, 127.24, 125.10, 71.23, 38.01.

6-((3,4-Dichlorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6f

Brown solid. Yield 88%. m.p. 216°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.11 (d, *J* = 7.30 Hz, 2H, H2, H6), 7.78 (d, *J* = 5.90 Hz, 2H, H6), 7.62–7.43 (m, 5H, H Ar), 4.60 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 139.11, 132.14, 131.85, 131.74, 130.83, 130.55, 127.23, 126.77, 37.60.

6-((3-Bromobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3, 4-b][1,3,4]thiadiazole, 6g

Brown solid. Yield 89%. m.p. 226°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.14 (d, *J* = 7.30 Hz, 2H, H2, H6), 7.75 (s, 1H, H2), 7.63–7.42 (m, 5H, H Ar), 7.11 (t, *J* = 7.50 Hz, 1H, H5), 4.64 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 131.80, 130.56, 127.24, 125.10, 71.23, 38.11..

6-((3-Chlorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3, 4-b][1,3,4]thiadiazole, 6h

Brown solid. Yield 95%. m.p. 217°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.16 (d, *J* = 6.60 Hz, 2H, H2, H6), 7.67–7.48 (m, 5H, H Ar), 7.37–7.29 (m, 2H, H Ar), 4.74 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 168.36, 157.68, 146.49, 143.04, 139.25, 137.48, 135.29, 134.41, 132.06, 131.25, 130.90, 129.26, 128.93, 128.78, 128.59, 128.43, 127.56, 127.43, 127.19, 126.62, 125.23, 122.92121.36, 115.09, 36.73.

6-((3-Fluorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3, 4-b][1,3,4]thiadiazole, 6i

Brown solid. Yield 87%. m.p. 217°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.13 (d, *J* = 6.10 Hz, 2H, H2, H6), 7.60–7.49 (m, 3H, H Ar), 7.42–7.29 (m, 3H, H Ar), 7.11 (t, *J* = 7.50 Hz, 1H, H4), 4.65 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 132.06, 131.93, 131.78, 130.54, 127.26, 126.71, 117.58, 117.22, 116.30, 115.96, 38.32.

6-((3-Methylbenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b][1,3,4]thiadiazole, 6j

Brown solid. Yield 93%. m.p. 214°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.17 (d, *J* = 6.60 Hz, 2H, H2, H6), 7.63–7.52 (m, 3H, H Ar), 7.45 (d, *J* = 6.60 Hz, 1H, H Ar), 7.26–7.10 (m, 3H, H Ar), 4.67 (s, 2H, CH_2), 2.36 (s, 3H, CH_3); ^{13}C NMR (62 MHz, DMSO-d_6): δ 132.01, 131.79, 131.70, 130.58, 129.82, 127.62, 127.62, 127.31, 126.83, 37.62, 20.31.

6-((2-Bromobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3, 4-b][1,3,4]thiadiazole, 6k

Brown solid. Yield 94%. m.p. 211°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.16 (d, *J* = 6.50 Hz, 2H, H2, H6), 7.70–7.49 (m, 5H, H Ar), 7.35 (d, *J* = 7.30 Hz, 1H, H Ar), 7.27 (d, *J* = 8.00 Hz, 1H, H2, Ar), 4.72 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 133.29, 132.12, 131.76, 130.61, 129.64, 127.25, 126.77, 38.09.

6-((2-Chlorobenzyl)thio)-3-phenyl-[1,2,4]triazolo[3,4-b] [1,3,4]thiadiazole, 6l

Brown solid. Yield 86%. m.p. 225°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.15 (d, *J* = 8.20 Hz, 2H, H2, H6), 7.72–7.53 (m, 4H, H Ar), 7.50–7.44 (m, 1H, H Ar), 7.42–7.29 (m, 2H, H Ar), 4.65 (s, 2H, CH_2); ^{13}C NMR (62 MHz, DMSO-d_6): δ 168.36, 157.68, 146.49, 143.04, 139.25, 137.48, 135.29, 134.41, 132.06, 131.25, 130.90, 129.26, 128.93, 128.78, 128.59, 128.43, 127.56, 127.43, 127.19, 126.62, 125.23, 122.92121.36, 115.09, 36.73.

6-((2-Methylbenzyl)thio)-3-phenyl-[1,2,4]triazolo[3, 4-b][1,3,4]thiadiazole, 6m

Brown solid. Yield 85%. m.p. 213°C. ^{1}H NMR (250 MHz, DMSO-d_6): δ 8.16 (d, *J* = 7.10 Hz, 2H, H2, H6), 7.64–7.45 (m, 3H, H Ar), 7.26 (d, *J* = 7.60 Hz, 1H, H3), 7.12–7.02 (m, 2H, H Ar), 6.84 (d, *J* = 7.90 Hz, 1H, H2), 4.60 (s, 2H, CH_2), 3.62 (s, 3H, CH_3); ^{13}C NMR (62 MHz, DMSO-d_6): δ 131.77, 131.17, 130.57, 127.27, 126.78, 122.79, 116.25, 114.85, 56.49, 38.89.

Antifungal screening

The *in vitro* antifungal screening of the compounds **6a-m** were carried out against *Penicillium citrinum* and *Fusarium oxysporum* by poisoned food technique at 10, 100 and 1000 ppm concentration using griseofulvin and dithane M-45 as standards and by using Czapek's agar medium as described in the literature[73,74]. The test fungi were inoculated in the centre of the petridishes and incubated at 28±1°C for 96 hr. After this time, the percent inhibition of the mycelial growth compared with that in control dishes was recorded. Most of the screened compounds showed promising fungicidal activity at 1000 ppm concentration with both the test fungi *Penicillium citrinum* and *Fusarium oxysporum* (Table 1). Among the tested compounds **6c** and **6e** displayed fungicidal action comparable with griseofulvin and dithane M-45 at 1000 ppm concentration and inhibited 45−71% mycelial growth of both fungal species even at the lowest concentration. This demonstrates that the presence of [1,2,4]triazolo[3,4-b][1,3,4]thiadiazole nucleus resulted in appreciable enhancement of fungitoxicity of these compounds. The fact that both of these fungi have developed resistance to several fungicide groups made them optimal candidates as target organisms for ongoing research about the potential application of [1,2,4] triazolo [3,4-b] [1,3,4] thiadiazols and analogue compounds as reduced-risk fungicides.

For the most active compounds **6c** and **6e** it was ascertained whether they are fungistatic or fungicidal. Thus, following the procedure of Garber *et al*., compounds **6c**, **6e**, **6i** and **6j** were added separately to

Table 1 — Antifungal screening results of compounds **6a-m**

Compd	Average % inhibition after 96 h against					
	F. oxysporum			*P. citrinum*		
	1000 ppm	100 ppm	10 ppm	1000 ppm	100 ppm	10 ppm
6a	50	42	20	47	33	23
6b	62	56	31	51	44	31
6c	100	90	82	99	95	78
6d	61	51	30	48	40	24
6e	98	48	22	96	38	23
6f	45	38	18	54	28	25
6g	60	50	29	46	38	24
6h	78	67	61	76	64	53
6i	89	68	33	78	62	27
6j	79	52	27	88	48	21
6k	51	35	19	49	26	19
6l	69	59	51	77	61	53
6m	78	63	22	57	42	20
Dithane M-45	100	96	91	100	97	95
Griseofulvin	100	99	93	100	98	96

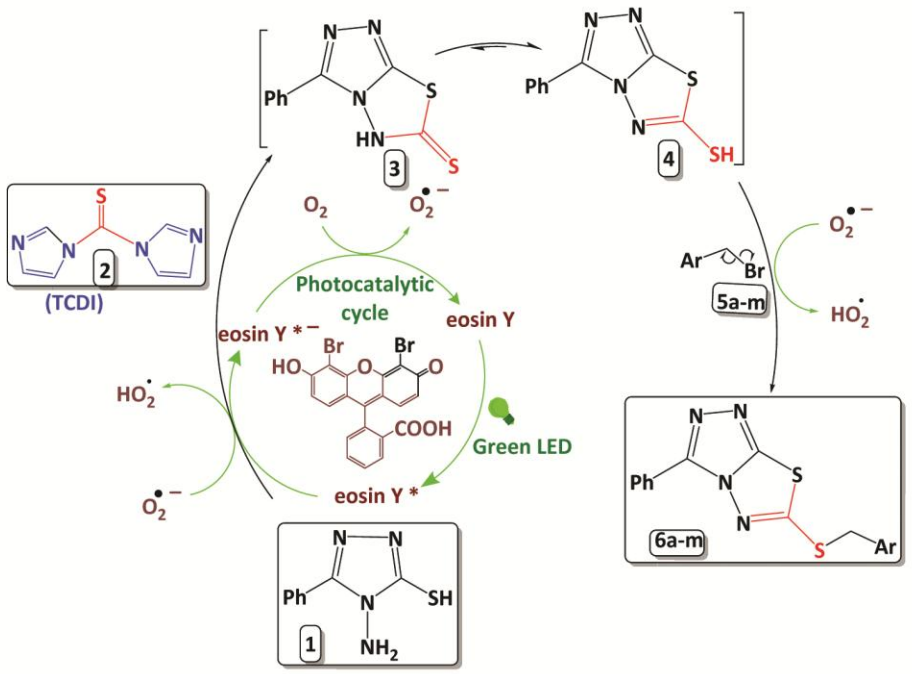
Czapek's agar medium in different petridishes to maintain the final concentrations[73,74] at their respective lethal dose (800, 700 and 200 ppm). The test fungi were inoculated in the centre of these petridishes and incubated at 28 ± 1°C for 96 hr, after stet time, the percent inhibition of mycelial growth compared with that in control dishes was recorded. Then the fungal disks were taken from the treated and control dishes, washed with sterilized double-distilled water, and reinoculated in fresh petridishes containing Czapek's agar medium only. The plates were incubated for 96 hr at 28 ± 1°C and the percent inhibition was recorded. The number of replicate assays in each case was three, and six replicate controls were used. It was found that compounds **6c**, **6e**, **6i** and **6j** caused complete inhibition of mycelial growth of the test fungi in treated as well as reinoculated dishes and hence were fungicidal.

$$\% \text{ inhibition} = 100 \times \frac{(\text{Average hyphal diameter in the control}) - (\text{Average hyphal diameter in the test})}{(\text{Average hyphal diameter in the control})}$$

Most of the screened compounds have significant fungitoxicity at 1000 ppm (Table 1) against both tested fungi, but their toxicity considerably decreased on dilution (100 and 10 ppm). Of the tested compounds, the most active, **6c** and **6e**, displayed fungicidal action comparable with that of griseofulvin and Dithane M-45 at 1000 ppm and inhibited 12−69% mycelial growth of both fungal species even at the lowest concentration. The present study indicates that the [1,2,4]triazolo framework incorporated with [3,4-b][1,3,4]thiadiazole nucleus reported herein might be useful for developing efficacious fungicides by a suitable combination of heterocyclic moiety and substituent present on the aromatic ring.

Results and Discussion

In appreciate our idea we started our investigation by 4-amino-5-phenyl-4H-1,2,4-triazole-3-thiol (**1**), 1,1′-Thiocarbonyldiimidazole (TCDI) (**2**) as a model substrate, Eosin-Y (2 Mol%) as catalyst under photochemical conditions in oxygen atmosphere (Scheme 1). Benzyl halide **5a-m** were added in the crude mixture of product. The mixture was irradiated with 18W green-LED under an air atmosphere at RT. With this positive result, we examined several organic dyes such as Methylene Blue, Rose Benzal and Rhodamine B to optimization reaction conditions. But it was observed that all of them gave lower yield than Eosin-Y (2 Mol%) (Table 2, entry 2-4). Next, we examined different solvents (Table 2, entry 5-8), and it was found that toluene gave the best results in comparison of other solvents (Table 2, entry 1). Furthermore, in this series we investigated the efficiency of Eosin-Y as photocatalyst by taking it 1 Mol% (60%; Table 2, entry 9), whereas its absence gave lower yield (35%; Table 2, entry 18). Next, we examined the effect of time on the yield of the compound and found that the highest yield was found if reaction was done 2 hrs. Further it is found that the yield was decreased in every other variation in time (Table 2, entry 12-14). Green color LEDs are important for good yield of isolated product because when used blue and white color LEDs got lower yield



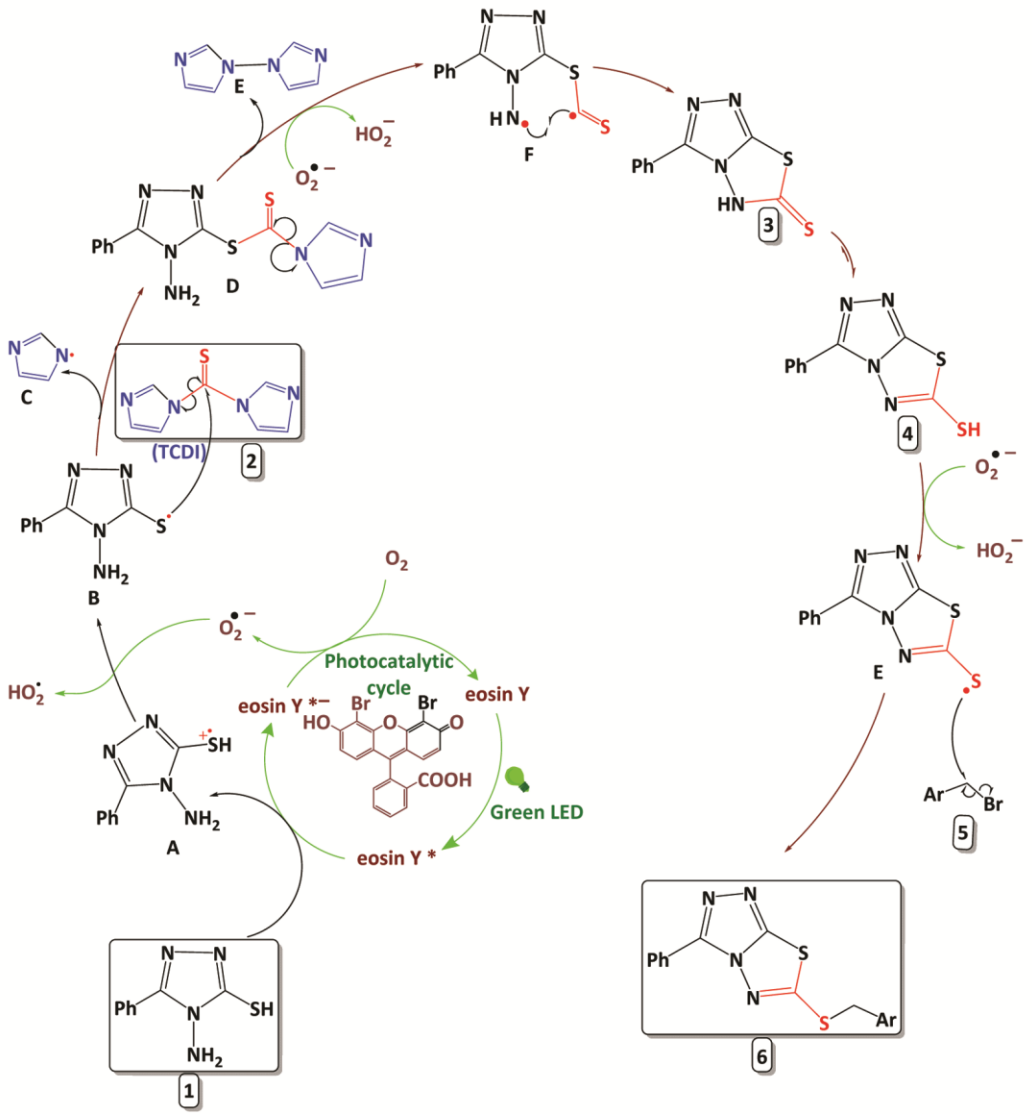
Compd	Ar	Compd	Ar	Compd	Ar
6a	C_6H_5 -	**6f**	3,4.$(Cl)_2$-C_6H_3 -	**6j**	3-CH_3.C_6H_4 -
6b	4-Br.C_6H_4 -	**6g**	3-Br.C_6H_4 -	**6k**	2-Br.C_6H_4 -
6c	4-Cl.C_6H_4 -	**6h**	3-Cl.C_6H_4 -	**6l**	2-Cl.C_6H_4 -
6d	4-F.C_6H_4 -	**6i**	3-F.C_6H_4 -	**6m**	2-CH_3.C_6H_4 -
6e	4-NO_2.C_6H_4 -				

Scheme 1 — Synthesis of triazolo [3,4-b] [1,3,4] thiadiazols

Table 2 — Optimization of reaction conditions [a]

Entry	Photocatalyst	Catalyst loading (mol%)	LED (18W)	Solvent	Time (h)	Yield [b] (%)
1.	Eosin-Y	2	Green	Toluene	2	93
2.	Methylene Blue	2	Green	Toluene	2	88
3.	Rose Bengal	2	Green	Toluene	2	85
4.	Rhodamine B	2	Green	Toluene	2	81
5.	Eosin-Y	2	Green	MeOH	2	82
6.	Eosin-Y	2	Green	EtOH	2	85
7.	Eosin-Y	2	Green	MeCN	2	68
8.	Eosin-Y	2	Green	DCM	2	71
9.	Eosin-Y	1	Green	Toluene	2	60
10.	Eosin-Y	3	Green	Toluene	2	93
11.	Eosin-Y	4	Green	Toluene	2	93
12.	Eosin-Y	2	Green	H_2O	1.50	72
13.	Eosin-Y	2	Green	H_2O	1.40	68
14.	Eosin-Y	2	Green	H_2O	1.30	54
15.	Eosin-Y	2	Blue	H_2O	2	90
16.	Eosin-Y	2	White	H_2O	2	87
17.	Eosin-Y	2	Dark	H_2O	60	37 [c]
18.	–	–	Green	H_2O	60	35 [d]

[a] Reaction conditions: **1** (1.5 mmol), **2** (1.5 mmol), 5**a** (1.5 mmol) catalyst (mol%), in 3 mL solvent irradiated using high power green LEDs [18W] at RT.
[b] Isolated yield of the pure product 6**a**.
[c] Reaction was performed in the dark.
[d] Reaction was carried out without the catalyst.



Scheme 2 — Proposed mechanism of reaction

(Table 2, entry 15-16). In dark we got very low yield of product (37%; Table 2, entry 18).

After optimizing the above-mentioned reaction condition the comprehensive approach of this process was investigated by using a variety of Benzyl halide **5a-m** in presence visible light (Green LEDs) with Eosin-Y (2 Mol%) using toluene as solvent at room temperature. The results of this study are mentioned in Table 2. Interestingly, it is found that the substrate used in the reaction and the yield of the product obtained show that the reaction using multiple substrates at the *ortho*, *meta* and *para* positions of the benzyl halide **5a-m** ring have given a positive contribution in getting good to excellent yield of the product.

Although, the exact reaction mechanism is not clear but we try to proposed a feasible mechanism for this reaction (Scheme 2). Initially, Eosin Y is irradiated by green LED light to produce the excited state eosin Y*. Excited state eosin Y* obtains an electron from 4-amino-5-phenyl-4*H*-1,2,4-triazole-3-thiol (**1**) affording the eosin $Y^{\bullet-}$ radical anion and sulphur radical cation (**A**). Subsequently, the oxidation of eosin $Y^{\bullet-}$ by dioxygen (air) generates the ground state Eosin Y and $O_2^{\bullet-}$. Then, the deprotonation of the sulphur radical cation (**A**) by $O_2^{\bullet-}$ gives the hydroperoxide radical species ($HO_2^{\bullet}$) and sulphur radical (**B**). Next, the addition of sulphur radical (**B**) to 1,1′-Thiocarbonyldiimidazole (TCDI) (**2**) affords (**D**), which is further oxidized by $O_2^{\bullet-}$ to

hydroperoxide radical species ($HO_2^{\bullet}$) and gives dimer of imidazole **E** and di-radical **F.** The di-radical **F** cyclises to **3**, which is tautomerizes into more stable aromatic thiol **4**. Further, thiol **4** oxidized by $O_2^{\bullet-}$ to ($HO_2^{\bullet}$) hydroperoxide radical species gives sulphur radical **E**. This sulphur radical **E** reacts with **5** to give product **6**.

Acknowledgements

The authors are grateful for financial support provided by University Grants Commission India (UGC start-up Project No. F.30-461/2019, BSR).

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