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Der Pharma Chemica, 2012, 4(5):2042-2046
(http://derpharmachemica.com/archive.html)

ISSN 0975-413X
CODEN (USA): PCHHAX

Synthesis, structural study and biological activity of bridgehead nitrogen containing triazolo-thiadiazinone heterocycles

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ABSTRACT

A facile synthesis of 7-[substituted]-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-ones have been carried out by reacting the 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one with different aromatic aldehydes in presence of fused sodium acetate. 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one was prepared by reacting the mixture of chloro acetic acid and fused sodium acetate with 4-amino-3-mercapto-5-pyridin-4-yl-4H-[1,2,4]-triazole. The latter was synthesized by reacting isoniazide with carbondisulphide and potassium hydroxide followed by the addition of hydrazine hydrate. The structures of synthesized compounds have been established on the basis of chemical transformation, elemental analysis, equivalent weight determination and IR, ^{1}H-NMR spectral studies. The title compounds have been assayed for their biological activity against gram-positive as well as gram-negative microorgansms.

Keywords: Synthesis, biological activity, triazolo-thiadiazin-6-ones.

INTRODUCTION

The heterocyclic compounds and especially those containing sulphur and nitrogen atoms possess a wide variety of biological activities [1,2]. Therapeutic effect of 1,2,4-triazole and 1,2,4-triazole-3-one containing compounds have been well studied for a number of pathological conditions including inflammation, cancer, pain, tuberculosis and hypertension [3,4]. 1,2,4-triazoles fused with 1,3,4-thiadiazines are found to possess diverse applications in the field of medicine [5,6]. Triazolo-thiadiazines are reported to show a broad spectrum of pharmacologicallly important properties like antifungal [7], antibacterial [8], antiviral [9], anthelmentic [10], antitumor [11], anti-inflammatory [12], antituberculor [13], diuretics [14], anticancer [15] and hypoglycaemic agents [16]. These two fused systems are reported to possess significant CNS depressant, herbicidal, anthelmintic activities and have been widely used in pharmaceutical and agrochemical industry [17]. In view of these findings about the utility of fused heterocyclic compounds in various fields and as a part of wider programme to provide alternative routes for the synthesis of 5 and 6 membered heterocyclic compounds [18-20], we report herein the synthesis of substituted-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-ones.

MATERIALS AND METHODS

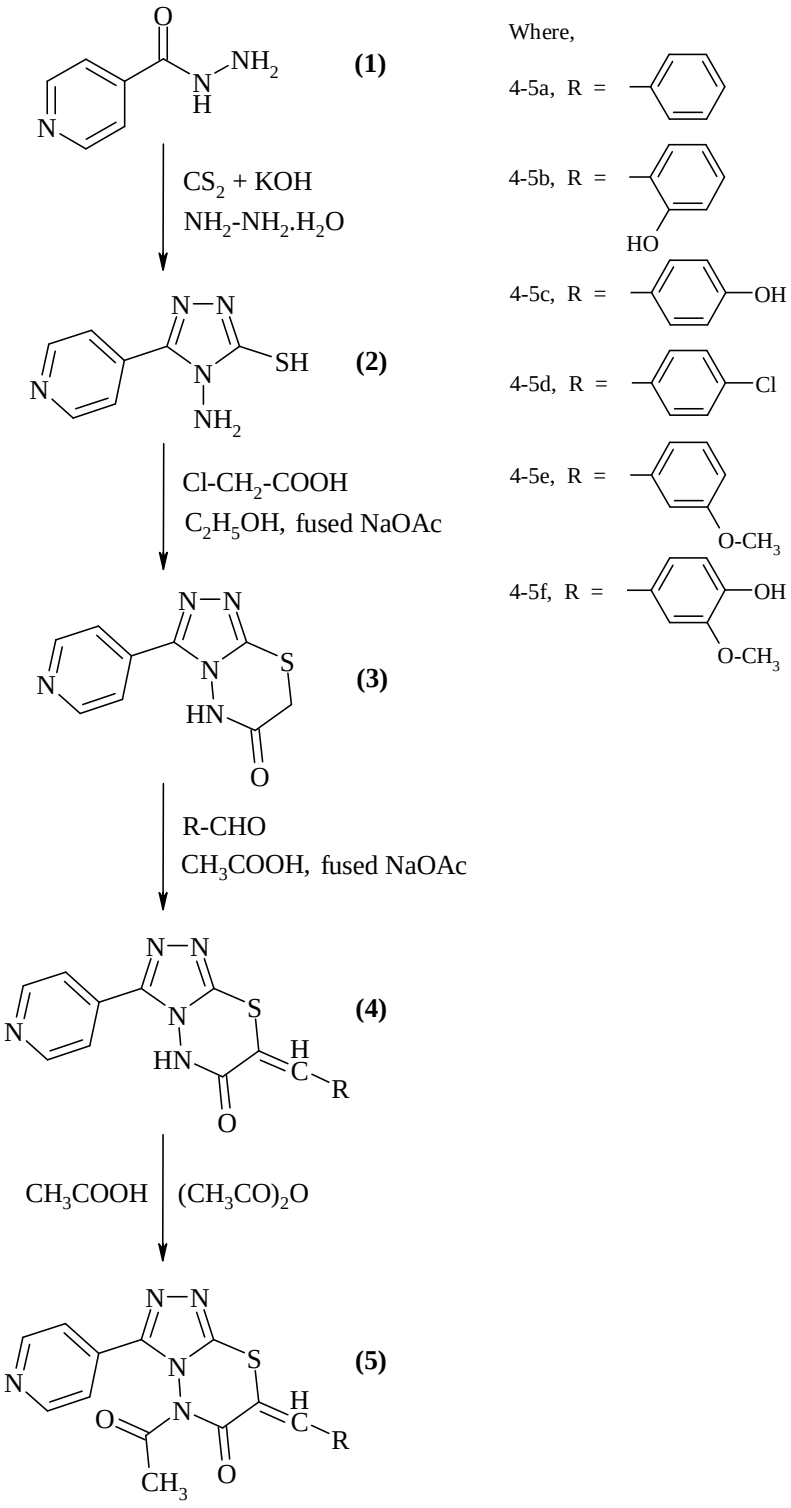
The melting points of all synthesized compounds were recorded using hot paraffin-bath and are uncorrected. Chemicals used were of AR grade. ^{1}H NMR spectra were recorded with TMS as internal standard using $CDCl_3$ and DMSO-d_6 as solvents. IR spectra were recorded on Perkin-Elmer spectrophotometer in the range 4000-400 cm^{-1} in nujol mull and as KBr pellete. Purity of the compounds was checked on silica gel-G plates by TLC.

Synthesis of 4-amino-3-mercapto-5-pyridin-4-yl-4H-[1,2,4]-triazole (2).
The compound 4-amino-3-mercapto-5-pyridin-4-yl-4H-[1,2,4]-triazole (**2**) was prepared by the interaction of isoniazide (**1**) (0.01 mole) with carbondisulphide (0.01 mole) and potassium hydroxide (1 mole, 10 mL) followed by the dropwise addition of hydrazine hydrate (0.01 mole) with constant stirring. The stirring was continued for 30 minutes at room temperature. The reaction mixture was cooled and poured in distilled water, a white precipitate was obtained. It was washed with water and recrystallized from ethanol, (**2**) (85%), m.p. 145^{0}C. (Found: C, 43.11; H, 3.31; N, 35.82; S, 16.08. Calcd. for $C_7H_7N_5S$: C, 43.52; H, 3.62; N, 36.26; S, 16.58%); ν_{max} 3423, 3370 (NH), 1682 (C=N), 1298 (C-N), 1210 (N-N), 758 cm^{-1} (C-S) [21,22].

Synthesis of 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (3).
The mixture of 4-amino-3-mercapto-5-pyridin-4-yl-4H-[1,2,4]-triazole (0.01 mole) and chloro acetic acid (0.01 mole) was refluxed in presence of fused sodium acetate (0.02 mole) using ethanol (15 mL) as a solvent for 4 hr. The reaction mixture was concentrated, cooled and poured in distilled water, a white coloured precipitate was obtained. It was crystallized from ethanol and identified as 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (**3**) (80%), m.p. 156°C. (Found: C, 46.25; H, 2.93; N, 29.88; S, 13.66. Calcd. for $C_9H_7N_5OS$: C, 46.35; H, 3.00; N, 30.04; S, 13.73%); ν_{max} 3316 (NH), 1710 (C=O), 1522 (C=N), 1294 (C-N), 1223 (N-N), 751 cm^{-1} (C-S); δ ($CDCl_3$+DMSO-d_6) 6.77-7.92 (4H, m, Ar-H), 4.56 (1H, s, NH), 2.21 (2H, s, CH).

Synthesis of 7-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (4a).
The mixture of 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (**3**) (0.01 mole) and benzaldehyde (0.01 mole) was refluxed in presence of fused sodium acetate (0.02 mole) using glacial acetic acid (15 mL) as a solvent for 1.5 hr. The reaction mixture was cooled and poured on ice, a white coloured precipitate was obtained. It was crystallized from ethanol and identified as 7-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (**4a**) (75%), m.p. 162°C. (Found: C, 58.37; H, 3.30; N, 21.41; S, 9.98. Calcd. for $C_{16}H_{11}N_5OS$: C, 59.81; H, 3.42; N, 21.80; S, 9.96%); ν_{max} 3307 (NH), 1773 (C=O), 1496 (C=N), 1303 (C-N), 1226 (N-N), 767 cm^{-1} (C-S); δ ($CDCl_3$+DMSO-d_6) 11.62 (1H, s, CO-NH), 7.28-7.37 (9H, m, Ar-H), 3.36 (1H, s, CH). This reaction was extended to synthesize other compounds (**4b-f**): (**4b**) (72%), m.p.159^{0}C (Found: C, 56.22; H, 3.29; N, 20.68; S, 9.41. Calcd. for $C_{16}H_{11}N_5O_2S$: C, 56.97; H, 3.26; N, 20.77; S, 9.49%); ν_{max} 3528 (OH), 3327 (NH), 1721 (C=O), 1552 (C=N), 1326 (C-O), 1292 (C-N), 1214 (N-N), 760 cm^{-1} (C-S); δ ($CDCl_3$+DMSO-d_6) 11.18 (1H, s, CO-NH), 8.56 (1H, s, OH), 7.12-7.65 (8H, m, Ar-H), 3.26 (1H, s, CH); (**4c**) (72%), m.p. 165^{0}C (Found: C, 56.41; H, 3.11; N, 20.81; S, 9.36. Calcd. for $C_{16}H_{11}N_5O_2S$: C, 56.97; H, 3.26; N, 20.77; S, 9.49%); (**4d**) (78%), m.p. 150^{0}C (Found: C, 53.52; H, 2.77; N, 19.70; S, 8.89. Calcd. for $C_{16}H_{10}N_5OSCl$: C, 54.00; H, 2.81; N, 19.69; S, 9.00%); (**4e**) (72%), m.p. 160^{0}C (Found: C, 58.03; H, 3.62; N, 19.76; S,9.05. Calcd. for $C_{17}H_{13}N_5O_2S$: C, 58.11; H, 3.70; N, 19.94; S, 9.11%); (**4f**) (70%), m.p. 177^{0}C (Found: C, 54.84; H, 3.34; N, 19.11; S, 8.63. Calcd. for $C_{17}H_{13}N_5O_3S$: C, 55.58; H, 3.54; N, 19.07; S, 8.71%).

Synthesis of 5-Acetyl-7-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (5a).
A mixture of 7-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (**4a**) (0.01 mol) and acetic anhydride (0.01 mol) in glacial acetic acid (10 mL) was refluxed for 2 hr. The reaction mixture was cooled and poured in a little crushed ice with water, a pale yellow coloured solid precipitated was crystallised from aqueous ethanol to give (**5a**) (75%), m.p.174^{0}C (Found: C, 58.98; H, 3.48; N, 19.22; S, 8.66. Calcd. for $C_{18}H_{13}N_5O_2S$: C, 59.50; H, 3.58; N, 19.28; S, 8.81%); ν_{max} 1701 (C=O), 1505 (C=N), 1306 (C-N), 1221 (N-N), 745 cm^{-1} (C-S); δ ($CDCl_3$+DMSO-d_6) 7.03-8.12 (9H, m, Ar-H), 3.49 (3H, s, CO-CH_3), 3.18 (1H, s, CH). This reaction was extended to synthesize other acetyl derivatives (**5b-f**) from (**4b-f**) respectively: (**5b**) (72%), m.p. 171^{0}C; (**5c**) (70%), m.p. 151^{0}C; (**5d**) (75%), m.p. 165^{0}C; (**5e**) (72%), m.p. 183^{0}C; (**5f**) (75%), m.p. 191^{0}C.



Scheme 1

RESULTS AND DISCUSSION

The parent compound 4-amino-3-mercapto-5-pyridin-4-yl-4H-[1,2,4]-triazole (**2**) was prepared by the interaction of isoniazide (**1**) (0.01 mole) with carbondisulphide (0.01 mole) and potassium hydroxide (1 mole, 10 mL) followed by

the dropwise addition of hydrazine hydrate (0.01 mole) with constant stirring. It was transformed into 3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-one (**3**) by condensing it with chloro acetic acid (0.01 mole) in presence of fused sodium acetate (0.02 mole) using ethanol as a solvent for 4 hr. The compound (**3**) was then transformed into 7-[substituted]-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-ones (**4a-f**) by reacting it with mixture different aromatic aldehydes (0.01 mole) and fused sodium acetate (0.02 mole) using glacial acetic acid as a solvent for 1.5 hr. The reaction mixture was cooled and poured on ice. The resulting white precipitate was crystallized from aqueous ethanol. Compounds (**4a-f**) on acylation with mixture acetic anhydride and glacial acetic acid afforded monoacetyl derivatives (**5a-f**) (**Scheme 1**).

Biological activity

The synthesized compounds (**4a-f**) were screened for their antibacterial activity using cup plate diffusion method [23,24]. The bacterial organisms used included both gram-positive as well as gram-negative strains like *E. coli*, *S. aureus*, *S. typhi*, *B. subtilis* and *A. aerogenes*. Sensitivity plates were seeded with a bacterial innoculum of $1x10^6$ CIU ml^{-1} and each well (diameter 10 mm) was loaded with 0.1 ml of test compound solution (1000 µg ml^{-1}) in DMF, so that concentration of each test compound was 100 µg ml^{-1}. The zones of inhibition were recorded after incubation for 24 hr. at 37^0C, using Vernier caliper. Inhibition zone record of the compounds clearly indicated that (**4e**) and (**4f**) were highly active against *S. aureus*, *S. typhi* and moderately active against *E. coli*, *A. aerogenes*. Majority of the compounds were found inactive against *B. subtilis* (**Table 1**).

To determine minimum inhibitory concentration (MIC), the serial dilution technique [25] was followed using nutrient broth medium. The MIC values of compounds (**4e**) and (**4f**), were determined against *S. aureus* and *S. typhi*, which were found to be 88 and 76 µg ml^{-1} respectively.

Screening of these compounds (**4a-f**) having the concentration 1%, for antifungal activity using paper disc method [26] showed that (**4c**), (**4e**) and (**4f**) were highly active against *A. niger*, whereas other compounds showed low to moderate activity. The zones of inhibition were recorded after incubation for 48 hr. at 37^0C (**Table 1**).

Table 1 - Antibacterial and antifungal activity of compounds (4a-f).

Compounds	Antibacterial activity					Antifungal activity
	E. coli	*S. aureus*	*S. typhi*	*B. subtilis*	*A. aerogenes*	*A. niger* (Conc. 1%)
4a	+	++	–	+	+	–
4b	++	++	++	+	++	+
4c	+	+	+	–	+	+++
4d	–	+	++	–	–	+
4e	++	+++	+++	+	++	+++
4f	++	+++	+++	+	++	+++

(–) : Inactive (12 mm and less) *(+) : Weakly active (13-16 mm)*
(++) : Moderately active (17-20 mm) *(+++) : Highly active (21 mm and above)*

CONCLUSION

In present work, synthesis of 7-[substituted]-benzylidene-3-pyridin-4-yl-[1,2,4]-triazolo-[3,4-b]-[1,3,4]-thiadiazin-6-ones (**4a-f**) and its acetyl derivatives (**5a-f**) have been reported from isoniazide as the starting material. The method applied for the synthesis is quite efficient. Study of biological activity of these compounds revealed that, most of the compounds have better antibacterial and antifungal activities.

Acknowledgement

Thanks are due to Director, R.S.I.C., Central Drug Research Institute, Chandigarh for providing analytical and spectral data. Author is thankful to Mr. Gopal D. Gole and Ms. Vaishali R. Patil for their generous help during the work and also to Dr. V. D. Nanoty, Principal, Shri Radhakisan Laxminarayan Toshniwal College of Science, Akola for providing necessary facilities.

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