eISSN: 2231-0541 CAS CODEN: PHARN8 An ELSEVIER Covered Journal

PHARMANEST

An International Journal of Advances in Pharmaceutical Sciences

Volume 4 | Issue 6 | November-December 2013 | Pages 1383-1391

Original Research Article

SYNTHESIS AND ANTIBACTERIAL EVALUATION OF SOME N-(*P*-SUBSTITUTED BENZYLIDENE)-5-PROPYL-1, 3, 4-THIADIAZOLE-2-AMINES

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Received: 03-09-2013 Revised: 11-09-2013

Accepted: 21-10-2013 Available online: 01-11-2013

ABSTRACT

A series of Schiff's bases *i.e.*, N-(*p*-substituted benzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amines were synthesized from 2-amino-5-propyl-1, 3, 4-thiadiazole **1** and evaluated for their *in vitro* antibacterial activity. Reaction of thiosemicarbazide with butanoic acid in presence of concentrated sulfuric acid furnished the compound **1** which on further reaction with different *p*-substituted benzaldehydes yielded the Schiff's bases **2.** These compounds were characterized by spectral analysis. All the synthesized compounds were screened for their *in vitro* for their antibacterial activity against two Gram positive bacterial strains (*Bacillus subtilis* and *Staphylococcus aureus*) and two Gram negative bacterial strains (*Escherichia coli* and *Pseudomonas aeruginosa*) and their minimum inhibitory concentration (MIC) were determined.

Key words: 1, 3, 4-Thiadiazole, Schiff's base, antibacterial, minimum inhibitory concentration (MIC).

INTRODUCTION

The extensive utilization of chemotherapeutic agents for the management of infectious diseases leads to the development of microbial resistance to existing drugs. The appearance of resistance to the major classes of antibacterial drugs is recognized as a major health concern of world population. This opens the gate for the medicinal chemists for the development of novel antimicrobial drugs having a different mechanism of action to combat the problem of multidrug resistance [1]. Heterocyclic compounds continue to attract considerable interest due to their diverse biological activities. Amongst them five membered heterocyclic compounds occupy a unique place in the field of natural and synthetic organic chemistry. Five membered heterocycles like 1, 3, 4-thiadiazole and their derivatives possess interesting biological activities. When various functional groups are attached to1, 3, 4-thiadiazole nucleus, the resulting compounds interact with biological receptors and show outstanding properties. Compounds containing 1,3,4-thidiazole nucleus have been reported as antitumor agent [2], potent inhibitors of 5-lipoxygenase and cyclooxygenase [3], antimicrobials [4], anti-tuberculosis [5, 6], anti-inflammatory [7], antidepressant and anxiolytics [8], anticancer [9, 10], anthelmintic [11] etc. These reports including our ongoing research program in the field of synthesis and antimicrobial activity of medicinally important compounds [12-14] inspired us to undertake the synthesis of some N-(*p*-substituted benzylidene)-5-ethyl-1, 3, 4-thiadiazole-2-amines. The synthesized compounds were characterized on the basis of IR and ^{1}H NMR spectral data. All the compounds were screened for their *in vitro* antibacterial activity against two Gram positive strains (*Bacillus subtilis* and *Staphylococcus aureus*) and two Gram negative strains (*Escherichia coli* and *Pseudomonas aeruginosa*) respectively and their minimum inhibitory concentration (MIC) were also determined.

MATERIALS AND METHODS

Chemistry

All the chemical and reagents used were of analytical grade and all the reaction were monitored by thin layer chromatography (TLC) using silica gel G as stationary phase, different solvent systems as mobile phase and iodine vapors as detecting agent. Melting points of the compounds were determined in open capillary tube by Decible Melting Point Apparatus and were uncorrected. Proton NMR spectra were recorded on Bruker Avance II 400 NMR Spectrometer using tetra-methyl silane as internal standard. Infrared Spectra were recorded by Perkins Elmer IR spectrophotometer using KBr pellets.

Synthesis of 2-amino-5-propyl-1, 3, 4-thiadiazole (1)

Synthesis of compound **1** was carried out according to the procedure reported in the literature [15]. Butanoic acid (0.15 M) and thiosemecarbazide (0.125 M.) in concentrated sulfuric acid (25 mL) were heated at 80-90 ^{O}C on thermostatically controlled water bath for about 7 hr. After cooling, the content was poured on crushed ice. The acid was neutralized with dilute ammonia solution. The crude product was filtered and washed with several time with cold distilled water and then recrystallized from hot distilled water.

General procedure for the synthesis of N-(*p*-substituted benzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amines (2a-h)

2-Amino-5-propyle-1, 3, 4-thiadiazole (0.01 M) and different *p*-substituted benzaldehydes (0.011 M) were refluxed in methanol in presence of few drops of glacial acetic acid for about 4 hr. After completion of reaction excess of methanol was distilled off under reduced pressure. The crude product so obtained was recrystallized from methanol. Physicochemical data of the title compounds are presented in Table 1.

Table.1.Physicochemical data of N-(*p*-substituted benzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amines

Compound	R	Molecular Formula	M.P. (^{O}C)	% Yield
2a	H	$C_{12}H_{14}N_3S$	234-237	66.3
2b	Cl	$C_{12}H_{13}ClN_3S$	128-131	78.4
2c	Br	$C_{12}H_{13}BrN_3S$	148-151	69.7
2d	NO_2	$C_{12}H_{13}N_4O_2S$	139-142	77.7
2e	F	$C_{12}H_{13}FN_3S$	170-173	70.6
2f	OCH_3	$C_{13}H_{16}N_3OS$	145-148	63.5
2g	CH_3	$C_{13}H_{16}N_3S$	207-210	64.4
2h	OH	$C_{12}H_{14}N_3OS$	190-193	79.1

Spectral Data

N-(benzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amine (2a)

IR (KBr, cm^{-1}): 643 (C–S–C), 1076 (Ar), 1030 (N–N),1567 (C=N), 810 (*p*-di-substituted benzene); ^{1}HNMR (DMSO, *d6*, δ ppm): 7.02–7.50 (m, 4H, Ar**H**), 8.17 (s, 1H, C**H**), 2.32-2.41 (q, 2H, C**H₂**), 1.60-1.63(m,2H,CH_2), 0.92 -1.09 (t, 3H, C**H₃**).

N-(4-chlorobenzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amine (2b)

IR (KBr, cm^{-1}): 649 (C–S–C), 1088 (Ar–Cl), 1039(N–N), 1575 (C=N), 817 (*p*- di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.01 -7.88 (m, 4H, Ar**H**), 8.19 (s, 1 H, C**H**), 2.43-2.87 (q, 2H, C**H₂**), 1.53-1.74 (m,2H,CH_2), 0.93-0.99 (t, 3H, C**H₃**).

N-(4-bromobenzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amine (2c)

IR (KBr, cm^{-1}): 642 (C–S–C), 1072 (Ar–Br), 1019 (N–N), 1571 (C=N), 803 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.15-7.45 (m, 4H, Ar**H**), 8.19 (s, 1H, C**H**), 2.21-2.25 (q, 2H, C**H₂**), 1.67-1.72 (m,2H,CH_2), 1.02-1.06 (t, 3H, C**H₃**).

N-(4-flurobenzylidene)-5- propyl -1, 3, 4-thiadiazole-2-amine (2d)

IR (KBr, cm^{-1}): 644 (C–S–C), 1328 (Ar–F), 1035 (N–N), 1581 (C=N), 814 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.16-7.43 (m, 4H, Ar**H**), 8.10 (s, 1H, C**H**), 2.45-2.50 (q, 2H, C**H₂**), 1.67-1.72 (m,2H,CH_2), 0.89.-0.94 (t, 3H, C**H₃**).

N-(4-nitrobenzylidene)-5- propyl -1, 3, 4-thiadiazole-2-amine (2e)

IR (KBr, cm^{-1}): 650 (C–S–C), 1328 (Ar–NO_2), 1036 (N–N), 1577 (C=N), 817 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.05-7.67 (m, 4H, Ar**H**), 8.16 (s, 1H, C**H**), 2.30-2.35 (q, 2H, C**H₂**), 1.61-1.66 (m,2H,CH_2), 0.91-0.98 (t, 3H, C**H₃**).

N-(4-methoxybenzylidene)-5- propyl -1, 3, 4-thiadiazole-2-amine (2f)

IR (KBr, cm^{-1}): 648 (C–S–C), 1330 (Ar–OC**H₃**), 1021 (N–N), 1574 (C=N), 818 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.01-7.47 (m, 4H, Ar**H**), 8.12 (s, 1H, C**H**), 3.71-3.73(t,3H,OCH_3), 2.17-2.21 (q, 2H, C**H₂**), 1.53-1.69 (m,2H,CH_2), 0.99-1.05 (t, 3H, C**H₃**).

N-(4-methylbenzylidene)-5- propyle-1, 3, 4-thiadiazole-2-amine (2g)

IR (KBr, cm^{-1}): 646 (C–S–C), 1323 (Ar–CH_3), 1032 (N–N), 1572 (C=N), 811 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.00-7.50 (m, 4H, Ar**H**), 8.10 (s, 1H, C**H**), 2.50-2.91 (q, 2H, C**H₂**), 2.35-2.38(s,3H,CH_3)1.53-1.87 (m,2H,CH_2), 0.86-0.95 (t, 3H, C**H₃**).

N-(4-hydroxybenzylidene)-5- propyle -1, 3, 4-thiadiazole-2-amine (2h)

IR (KBr, cm^{-1}): 654 (C–S–C), 3301 (Ar-OH), 1036 (N–N), 1573 (C=N), 815 (*p*-di-substituted benzene); ^{1}H NMR (DMSO, *d6*, δ ppm): 7.03-7.23 (m, 4H, Ar**H**), 8.13 (s, 1H, C**H**), 2.42-2.51 (q, 2H, C**H**$_2$), 0.95-0.99 (t, 3H, C**H**$_3$), 4.95-5.03 (s, 1H, O**H**).

Antibacterial activity

All the title compounds were screened for their *in vitro* antibacterial activity against two Gram positive strains, *i.e.*, *Bacillus subtilis* (MTCC 16) and *Staphylococcus aureus* (MTCC 3160) and two Gram negative strains, *i.e.*, *Escherichia coli* (MTCC 40) and *Pseudomonas aeruginosa* (MTCC 424) respectively. Ciprofloxacin was used as the standard drug for the present study. Serial two fold dilution technique was used for the study of antibacterial activity [16]. A stock solution (10 µg/mL) of all the title compounds and standard drug was prepared in dimethyl sulfoxide. Sterilized double strength nutrient broth (DSNB) was used as a growth media. The stock solution was serially diluted by DSNB aseptically to give concentrations of 5.0–0.01 µg/mL into a series of sterilized culture tubes. All the tubes were inoculated by bacterial strain. The inoculum's size was approximately 10^6 colony forming units (CFU/mL). The inoculated tubes were incubated for 24 h at 37(±1) °C. After 24 h, the inoculated culture tubes were macroscopically examined for turbidity. The culture tube showing turbidity (lower concentration) and the culture tube showing no turbidity (higher concentration) gave the minimum inhibitory concentration (MIC) for the compound. The MIC for the title compounds and the standard drug, *i.e.*, ciprofloxacin are presented in Table 2.

Table.2.Antibacterial activity of N-(*p*-substituted benzylidene)-5-propyl-1, 3, 4-thiadiazole-2-amines

Compound	Minimum inhibitory concentration (MIC µg/ mL)			
	S. aureus MTCC 3160	***B. subtilis*** MTCC 16	***E. coli*** MTCC 40	***P. aeruginosa*** MTCC 424
2a	0.85	0.85	0.75	0.75
2b	0.75	0.70	0.60	0.65
2c	0.75	0.70	0.60	0.65
2d	0.55	0.55	0.50	0.50
2e	0.50	0.50	0.50	0.50
2f	0.95	0.95	0.95	0.95
2g	0.95	0.95	0.85	0.85
2h	0.65	0.65	0.55	0.60
Ciprofloxacin	0.15	0.12	0.01	0.25

RESULTS

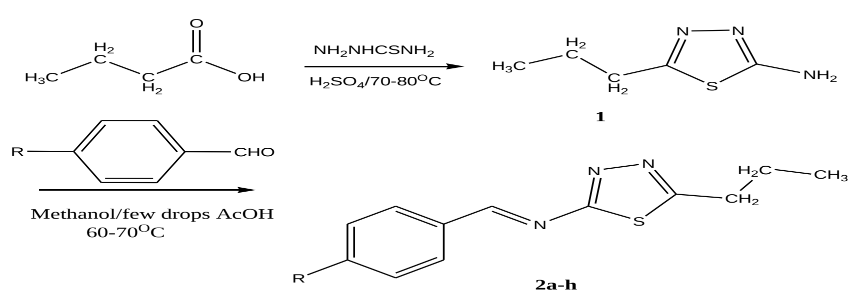
The compound **2e** shows best activity against gram positive and gram negative bacteria. The compound **2d** shows best activity against gram negative. The compound **2h** shows better activity against gram negative and gram positive. The compound **2b** and **2c** shows good activity against gram negative and gram positive. The compound **2a** and shows weak activity against gram positive and gram negative. The compound **2f** shows weakest activity against gram positive and gram negative.

DISCUSSION

Chemistry

The syntheses of N-(*p*-substituted benzylidene)-5-propyl-1, 3, 4 -thiadiazole-2-amines were achieved following the steps outlined in the **Scheme 1**. Cyclization of thiosemicarbazide with butanoic acid in presence of sulfuric acid furnished 5-propyl-2-amino-1, 3, 4-thiadiazole **1**.

Reaction of compound **1** with different *p*-substituted benzaldehydes in presence of few drops of glacial acetic acid yielded the Schiff's bases *i.e.*, N-(*p*-substituted benzylidene)-5-prppyl-1, 3, 4-thiadiazole-2-amines **2**. All the compounds were obtained in good yield. All the compounds were characterized by spectral analysis. The IR spectra of each compounds show a band for (C–S–C) stretching vibrations near 644 cm^{-1} and (N–N) stretching vibrations were observed near 1023 cm^{-1}. The bending vibrations for *p*-di-substituted benzene were appeared in the range of 803-820 cm^{-1}. In case of ^1H NMR, the chemical shift value for methyl and methylene protons appeared as multiplate, triplet and quartet at 1.53-1.87 δ (ppm), 0.98-1.90 δ (ppm) and 2.17-2.87 δ (ppm) respectively whereas methine proton was appeared as singlet and observed at 8.10-8.19 δ (ppm). The chemical shift value for aromatic protons was observed in the range of 7.00-7.88 δ (ppm) and appeared as multiplet.



Compound	R
2a	H
2b	Cl
2c	Br
2d	F
2e	NO_2
2f	OCH_3
2g	CH_3
2h	OH

Scheme 1: Synthesis of N-(*p*-substituted benzylidene)-5-propyl-1,3,4-thiadiazole-2-amines

Antibacterial Activity

All the synthesized title compounds were screened for their *in vitro* antibacterial activity against and two Gram positive bacterial strains *i.e.*, *Bacillus subtilis* (MTCC 16) and *Staphylococcus aureus* (MTCC 3160) and two Gram negative bacterial strains *i.e.*, *Escherichia coli* (MTCC 40) and *Pseudomonas aeruginosa* (MTCC 424) respectively and their minimum inhibitory concentration (MIC) were determined. A perusal of the table 2 shows that all the title compounds were found to be active against all the bacterial strains used in this study. The minimum inhibitory concentrations (MIC) of the title compounds 2a-h were found to be in the range of 0.95-0.50µg/ml against all the bacterial strains screened in the present study. The MICs of the title compounds containing electron withdrawing groups like fluoro, chloro, bromo or nitro were found somewhat less than the compounds containing electron releasing groups like methyl and methoxy. The reference standard ciprofloxacin inhibited Gram negative bacteria viz., *E. coli* and *P. aeruginosa* at a MIC of 0.01µg/ml and 0.25µg/ml respectively whereas against Gram positive bacteria viz., *S. aureus* and *B. subtilis* MIC was found to be 0.15µg/ml and 0.12µg/ml respectively. The results of the MIC for the standard drug, ciprofloxacin, against the bacterial strains used were found to be within the range as reported in the literature [17-18].

CONCLUSION

Present study describes the synthesis of a series of Schiff's bases of 5-propyl -1, 3, 4-thiadiazole-2-amine. The compounds were characterized by spectral techniques such as IR and proton NMR spectra. All the title compounds were screened for their *in vitro* antibacterial activity against *Bacillus subtilis*, *Staphylococcus aureus* (Gram positive) and *Escherichia coli*, *Pseudomonas aeruginosa* (Gram negative) and their minimum inhibitory concentration (MIC) were determined. The results of antibacterial activity showed that compounds containing electron withdrawing groups e.g., chloro, bromo, fluoro or nitro were found to be more active than the compounds containing electron releasing groups such as methyl, hydroxy and methoxy. These results suggest that some more compounds using different aliphatic acids and hetero-aromatic aldehydes or ketones should be synthesized and screened for their antibacterial activity to explore the possibility of Schiff's bases of 5-alkyl-1, 3, 4-thiadiazole-2-amine as a new series of antibacterial.

ACKNOWLEDGEMENTS

The authors are thankful to Chairman, Department of Pharmaceutical Sciences, Guru Jambheshwar University of Science and Technology, Hisar (Haryana) India for providing necessary facilities to carry out this work. Our sincere thanks are due to the Co-ordinator, Central Instrument Laboratory, Guru Jambheshwar University of Science and Technology, Hisar (Haryana), India for elemental and spectral analysis. The Director, IMTECH, Chandigarh is also duly acknowledged for providing bacterial strains.

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