



Synthesis of Novel 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine Derivatives and *In-vitro* Evaluation of their Antitumor and Antibacterial Activities

J. Paveendra ^a and H. M. Vagdevi ^{b*}

^a Department of Chemistry, Sahyadri Science College, Shivamogga-577203, India.

^b Sahyadri Science College, Shivamogga-577203, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Benzoxazole is one of the biologically important heterocyclic compounds, which shows remarkable pharmacological activities. In this work, 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine derivatives have been synthesized by using mild protocol under solvent free condition. Structures of the synthesized compounds have been confirmed through IR, ¹H NMR, ¹³C NMR and Mass spectral methods. All the compounds were assessed for their antitumor and antibacterial activities. 6h has found remarkable activity on both antitumor and antibacterial studies and 6g and 6a exhibited promising antibacterial and antitumor activity. Simple work up technique, good yield and use of environmental-friendly reagents are of the reaching features of the present work.

*Corresponding author: E-mail: vagdevihm17@gmail.com;

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1. INTRODUCTION

Benzoxazoles are found in important classes of bioactive compounds like antibacterial antibiotic, antistress, antitumor [1], anticancer [2,3], antioxidant, cyclooxygenase inhibitory, antifungal, 5HT₃ receptor antagonists, anticonvulsant, antiviral, antidepressant, antiulcer, anti-HIV-1, antitubercular, insecticidal and anti-inflammatory [4-9]. "On the other hand, amine derivatives have wide range of biological activities such as antiviral, anti-inflammatory, antitumor and anti-bacterial" [10].

Among many diseases, Cancer is the leading disease cause number of deaths worldwide [11]. Scientists develop more selective, effective, and safe drugs every day [12]. By reviewing the literature, we found that benzoxazole derivatives have important biological activities mainly antitumor [13–15] and antibacterial [16].

Based on the structure of benzoxazoles and reported derivatives [17-19], we designed the reactions and evaluated their antitumor activity against HepG2 and antimicrobial activity against *S. aureus*, *Bacillus subtilis*, Gram-negative *E. coli* and *Salmonella typhi* and *Shigella*.

Several protocols are available for the synthesis of heterocyclic compounds. Nowadays the concept of solvent free synthesis has been playing an important role in the synthesis. Therefore, there is a demand for efficient and ecofriendly methods for the preparation of these benzoxazoles. p-toluene sulfonic acid can be easily handled and easily separated from the mixture by filtration and washed from water.

2. METHODOLOGY

"Melting points were recorded on electro thermal melting point apparatus and are uncorrected. The purity and reaction progress of all the compounds were checked by TLC on silica gel plates using n-Hexane, ethyl acetate solvent system and spots located by UV and iodine chamber" [20]. All the chemicals used in this were purchased from Sigma-Aldrich and SD Fine. "IR spectra were recorded using KBr pellets on a Perkin Elmer Spectrophotometer. ¹H-NMR spectra on Agilent 400 MHz Spectrophotometer and chemical shifts were expressed as ppm and

TMS as internal standard. Mass spectra were recorded on Xevo G2-XS Qtof" [20].

2.1 Synthesis of 5-methyl-1,3-benzoxazole-2-thiol (2)

"2-Amino-4-methylphenol (1 g, 0.008mol, 1 eq) was reacted with KOH (0.54 g, 0.009 mol, 1.2 eq) in presence of methanol (50 mL) and stirred for 10 minute followed by the slow addition of CS₂ (0.64 mL, 0.009 mol, 1.2 eq) at room temperature. The reaction mass was refluxed for 6 h on water bath. The completion of the reaction was confirmed by TLC (Hexane: Ethyl acetate 9:1). Reaction mass was poured onto ice cold water and acidified with glacial acetic acid (pH 6). The obtained solid was filtered, dried, and recrystallized using ethanol" [20].

"Brown colour solid, yield (90%) MP (214-216°C); MS (m/z): 166 (M+), 167 (M+1)⁺; IR (KBr, ucm⁻¹): 3380; ¹H NMR (400 MH, DMSO) δ: 2.52 (s, 3H), 7.1-7.4 (m, 3H), 13.8 (br, SH); ¹³C NMR (DMSO): δ 21 (CH₃), 110 – 135 (aromatic carbons), 146 (C=N)" [20].

2.2 Synthesis of methyl-[(5-methyl-1,3-benzoxazol-2-yl)sulfanyl]- acetate (3)

"5-Methyl-1,3-benzoxazole-2-thiol 2 (2 g, 0.012 mol, 1 eq) was refluxed for 5 hours with ethyl chloroacetate (1.48 g, 0.012 mol, 1 eq) in presence of anhydrous potassium carbonate (6.02 g, 0.036 mol, 3 eq) in dry acetone, the progress of the reaction was monitored by TLC (Hexane: Ethyl acetate in 9:1 ratio). Reaction mixture was then poured onto ice water to get the pure crystals of 3" [20].

Dark brown colour solid, yield (85%), MP (85-88 °C); IR (KBr, ucm⁻¹): 1591 (C=N), 1710 (C=O); ¹H NMR (400 MH, DMSO) δ: 1.2 (t, 3H), 2.415-2.519 (s, 3H), 3.3 (s, 2H), 4.3 (q, 2H).7.1-7.5 (m, 3H); ¹³C NMR (DMSO): δ 14 (CH₃), 21 (CH₃), 34 (-O-CH₂), 62 (S-CH₂), 110 – 141 (aromatic carbons), 150 (CH₂CO), 168 (-C=O); MS (m/z): 252 (M+), 253 (M+1)⁺;

2.3 Synthesis of 2-hydrazinyl-5-methyl-1,3-benzoxazole (4)

Methyl-[(5-methyl-1,3-benzoxazol-2-yl) sulfanyl] acetate 3 (1 g, 0.0039 mol, 1eq) was added to

ethanol (50 mL) with stirring to dissolve and hydrazine hydrate (0.22 mL, 0.0047 mol, 1.2 eq). The reaction mixture was kept stirring for 3 hours and progress of the reaction was confirmed by TLC (Chloroform: Methanol in 7: 3 ratio). Reaction mixture was then poured into ice water to obtain compound 4.

White solid; yield (92%), MP (166-168 °C), 167 (M+1)⁺; IR (KBr, cm^{-1}): 1592 (C=N), 3330 (N-H); ¹H NMR (400 MH, DMSO) δ : 2.4 (s, 3H), 4.03 (br, 2H, NH₂), 7.07-7.48 (m, 3H), 9.4 (br, 1H, NH) (D₂O exchangeable); ¹³C NMR (DMSO): δ 21 (CH₃), 110 – 135 (aromatic carbons), 146 (C=N); MS (m/z): 166 (M+)

2.4 Synthesis of 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine (5)

The reaction of 2-hydrazinyl-5-methyl-1,3-benzoxazole 4 (1g, 0.006 mol, 1 eq) with 3-aminocrotonitrile (0.503 g, 0.006 mol, 1eq) was taken in a refluxing ethanol (50 mL) in the presence of sodium acetate monohydrate (0.50g, 0.006 mol, 1eq), the progress of the reaction was confirmed by TLC (Hexane: Ethyl acetate 7: 3 ratio), the reaction mixture was then poured onto ice water, filtered and washed with cold water. The product 5 was recrystallized by ethanol. Orange colour solid, yield (90%); IR (KBr, cm^{-1}): 3440, 3350(-NH str.), 1610 (-NH bend), 1280 (C-N str.), 760 (-NH wag.); ¹H NMR (400 MH, DMSO) δ : 2.44-2.52 (s, 3H), 3.32 (s, 3H), 5.3 (s, 1H), 6.1 (br, 2H, NH₂ D₂O exchangeable) 7.16-7.62 (m, 3H), ¹³C NMR (DMSO): 14 (CH₃), 21 (CH₃), 88 (-C- NH₂), δ 110 – 155 (Aromatic carbons); MS (m/z): 229 (M⁺), 230 (M+1)⁺.

2.5 General Procedure for the Synthesis of 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine Derivatives 6(a-h).

“A 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine 5 (1mmol) was ground with substituted aldehyde (1 mmol) for 15 to 20 minutes in an agate mortar and pestle at room temperature under solvent free conditions. The resulting mixture was added p-toluene sulfonic acid(1mmol). Then the mixture was ground for 20-30 minutes until TLC showed complete disappearance of the aldehyde. The reaction mixture was washed with water and further purified by recrystallization” [20].

2.6 3-Methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-N-(thiophen-2-ylmethyl)-1H-pyrazol-5-amine (6a)

Light pink colour solid, yield (91%); IR (cm^{-1}): 1176 (C-N str.), 621 (-NH wag.); ¹H NMR (400 MH, DMSO) δ : 2.10 (s, 3H), 2.38 (s, 3H), 5.6 (s, 1H), 6.10 (s, 2H), 7.01-7.58 (Ar, 6H); ¹³C NMR (DMSO): δ 13.42 (CH₃), 21.46 (CH₃), 30.15 (CH₂), 100-154 (Aromatic carbons); MS (m/z): 324(M⁺);

2.7 4-({[3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-yl] amino} methyl) phenol (6b)

Orange colour solid, yield (93%); IR (cm^{-1}): 1153 (C-N str.), 622 (-NH wag.); ¹H NMR (400 MH, DMSO) δ : 2.22 (s, 3H), 2.43 (s, 3H), 5.1 (s, 1H), 5.55 (s, 2H), 6.84 - 7.39 (Ar, 7H); ¹³C NMR (DMSO): δ 16.83 (1C, CH₃-C), 25.72 (1C, CH₃-C), 33.92 (1C, CH₂-C), 104-159 (16C-Ar-C); MS (m/z): 334(M⁺)

2.8 N-(furan-2-ylmethyl)-3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine (6c)

Brown colour solid, yield (85%); IR (cm^{-1}): 1153 (C-N str.), 622 (-NH wag.); ¹H NMR (400 MH, DMSO) δ : 2.39 (s, 3H), 2.47 (s, 3H), 5.38 (s, 1H), 6.11 (s, 2H), 7.10-7.66 (Ar-6H); ¹³C NMR (DMSO) δ : 13.15 (1C, CH₃-C), 21.46 (1C, CH₃-C), 28.94 (1C, CH₂-C), 98-154 (Aromatic carbons); MS (m/z): 308 (M⁺).

2.9 N-(4-chlorobenzyl)-3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine (6d)

Light brown colour solid, yield (87%); IR (cm^{-1}): 1150 (C-N str.), 622 (-NH wag.); ¹H NMR (400 MH, DMSO) δ : 2.41 (s, 3H), 2.42 (s, 3H), 5.12(s, 1H), 5.58(s, 2H), 6.84 (Ar-2H), 7.06-7.15 (Ar-3H), 7.17-7.33(Ar-6H); ¹³C NMR (DMSO) δ :12.86 (1C, CH₃-C), 21.60 (1C, CH₃-C), 34.11 (1C, CH₂-C), 100-154 (Aromatic carbons); MS (m/z): 352 (M⁺).

2.10 N-benzyl-3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine (6e)

Pink colour solid, yield (81%); IR (cm^{-1}): 1161 (C-N str.), 622 (-NH wag.); ¹H NMR (400 MH,

DMSO) δ : 2.42 (s, 6H), 5.17(s, 1H), 5.98(s, 2H), 6.84 (dd, Ar-2H), 7.24-7.28 (dd, Ar-1H), 7.27-7.38(dd, Ar-7H); ^{13}C NMR (DMSO) δ :12.90 (1C, CH₃-C), 21.60 (1C, CH₃-C), 34.49 (1C, CH₂-C), 100-154 (Aromatic carbons); MS (m/z): 318 (M⁺).

2.11 N-(3,4,5-trimethoxybenzyl)-3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine (6f)

White colour solid, yield (88%); IR (cm⁻¹): 1161 (C-N str.), 622 (-NH wag.); ^1H NMR (400 MH, DMSO) δ :2.29 (s, 3H), 2.35(s, 3H), 3.71 (s, 3H), 3.78 (s, 3H), 3.93 (s, 3H) 5.01(s, 1H), 5.61(s, 2H), 6.61 (s, Ar-2H), 7.06-7.08 (dd, Ar-1H), 7.12 (s, Ar-1H), 7.410(s, Ar-1H); ^{13}C NMR (DMSO) δ :12.65 (1C, CH₃-C), 21.47 (1C, CH₃-C), 35.32 (1C, CH₂-C), 56.00 (2C, O-CH₃), 60.00 (1C, O-CH₃) 100-154 (Aromatic carbons); MS (m/z):408 (M⁺).

2.12 3-Methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-N-(2-nitrobenzyl)-1H-pyrazol-5-amine (6g)

Yellow color solid, yield (83%); IR (cm⁻¹): 1161 (C-N str.), 622 (-NH wag.); ^1H NMR (400 MH, DMSO) δ : 2.41 (s, 3H), 2.42 (s, 3H), 5.12(s, 1H), 5.58(s, 2H), 6.84 (dd, Ar-2H), 7.06-7.15 (dd, Ar-3H), 7.17-7.33(dd, Ar-6H); ^{13}C NMR (DMSO) δ :12.86 (1C, CH₃-C), 21.60 (1C, CH₃-C), 34.11 (1C, CH₂-C), 100-154 (Aromatic carbons); MS (m/z): 363 (M⁺).

2.13 3-Methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-N-(3-nitrobenzyl)-1H-pyrazol-5-amine (6h)

Yellow colour solid, yield (82%); IR (cm⁻¹): 1161 (C-N str.), 622 (-NH wag.); ^1H NMR (400 MH, DMSO) δ : 2.41 (s, 3H), 2.42 (s, 3H), 5.12(s, 1H), 5.58(s, 2H), 6.84 (dd, Ar-2H), 7.06-7.15 (dd, Ar-3H), 7.17-7.33(dd, Ar-6H); ^{13}C NMR (DMSO) δ :12.86 (1C, CH₃-C), 21.60 (1C, CH₃-C), 34.11 (1C, CH₂-C), 100-154 (Aromatic carbons);MS (m/z): 363 (M⁺).

2.14 Biological Activities

2.14.1 Antibacterial activity

Test bacterial cultures were procured from Microbial Type Culture Collection (MTCC) of

Institute of Microbial Technology, Chandigarh. "Cultures of Gram-positive bacteria *S. aureus* (MTCC 7443), *subtilis* (MTCC 121) and Gram-negative *E. coli* (MTCC 7410) and *Salmonella typhi* (MTCC 733) *Shigella gram negative* (MTCC 1457) were grown on nutrient agar media used for antibacterial activity assay" [21-24]. "Antibacterial activity of chemical compounds 5 and 6(a -g) was tested for dual-culture agar diffusion assay with some modifications. Petri dishes were prepared by pouring 20 ml of sterilized Nutrient agar media under aseptic condition and allowed to solidify. After solidification of the media, 100 μl of standardized test microbial inoculum of Gram-positive bacteria *S. aureus*, *B. subtilis* and Gram-negative bacteria *E.coli*, *Shigella and typhi*, were spread uniformly using glass loop. Different concentration 1 mg/ml and 0.5 mg/ml were tested diluting the sample with DMSO were added to plates for diffusion of antibacterial compounds, thereafter plates were incubated at 37°C for 24 h. The diameter of the inhibition zone around the discs is measured in millimeters (mm) and the average of three repeated agar discs were taken to assess the strength of antibacterial activity" [20].

2.14.2 Antitumor Activity

"The antitumor activities against HepG2, human liver cancer cell lines were estimated using the 3-[4,5-dimethyl-2-thiazolyl]-2,5-diphenyl-2H-tetrazolium bromide (MTT) assay, Cells were dispensed in a 96-well sterile microplate (5 \times 10⁴ cells/well) and incubated at 37°C with series of different concentrations, in DMSO, of 5 and 6(a - h) compounds for 48 h in a serum-free medium prior to the MTT assay" [24-26]. "After incubation, media were carefully removed, and 40 μL of MTT (2.5 mg/mL) was added to each well and then incubated for an additional 4 h" [20]. "The purple formazan dye crystals were solubilized by the addition of 200 μL of DMSO. The absorbance was measured at 570 nm using a multi-Mode micro plate reader analyzed using megalen software" [20]. "The relative cell viability was expressed as the mean percentage of viable cells compared to the untreated control cells. All experiments were conducted in triplicate and repeated in three different days. All the values were represented as mean \pm SD. IC50s were determined" [27].

Table 1. Antibacterial activity (Zone of Inhibition at 1 mg/ ml)

Sl no	Compounds	<i>S. aureus</i>	<i>B. subtilis</i>	<i>E. coli</i>	<i>S. typhi</i>	<i>Shigella</i>
1	5	4 mm	5 mm	6 mm	8 mm	6 mm
2	6a	13 mm	15 mm	16 mm	16 mm	16 mm
3	6b	-	-	-	-	-
4	6c	-	-	-	-	-
5	6d	-	-	-	-	-
6	6e	4 mm	5 mm	6 mm	8 mm	6 mm
7	6f	-	-	-	-	-
8	6g	13 mm	15 mm	16 mm	16 mm	16 mm
9	6h	13 mm	14 mm	16 mm	16 mm	16 mm

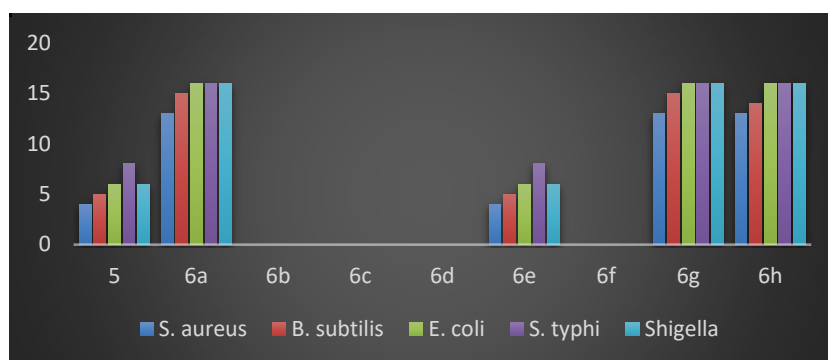


Fig. 1. Antibacterial activity (Zone of Inhibition at 1 mg/ ml)

Table 2. Antibacterial activity (Zone of Inhibition at 0.5 mg/ ml)

Sl no	Compounds	<i>S. aureus</i>	<i>B. subtilis</i>	<i>E. coli</i>	<i>S. typhi</i>	<i>Shigella</i>
1	5	-	-	-	-	-
2	6a	9 mm	9 mm	12 mm	12 mm	12 mm
3	6b	-	-	-	-	-
4	6c	-	-	-	-	-
5	6d	-	-	-	-	-
6	6e	-	-	-	-	-
7	6f	-	-	-	-	-
8	6g	9 mm	9 mm	12 mm	12 mm	12 mm
9	6h	9 mm	9 mm	12 mm	12 mm	12 mm

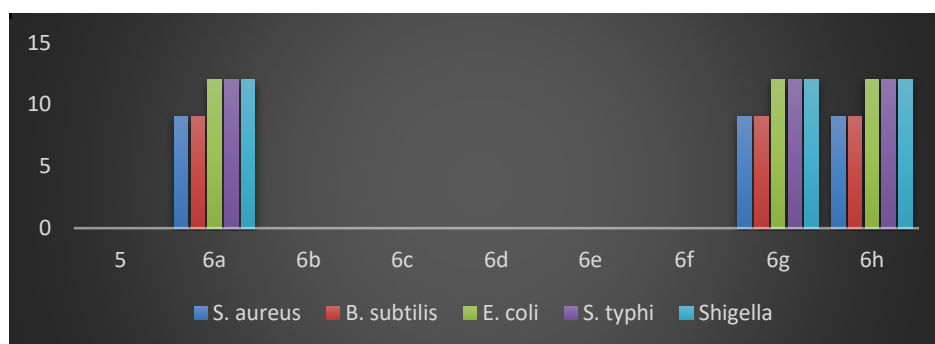


Fig. 2. Antibacterial activity (Zone of Inhibition at 0.5 mg/ ml)

Table 3. Antitumor activity

SI No.	Compound Name	% Of inhibition	IC 50 Value
1	5	35.6 %	72.6
2	6a	52.20%	99.10
3	6b	19.98 %	41.44
4	6c	22.96 %	43.73
5	6d	24.62 %	48.14
6	6e	25.69%	55.67
7	6f	33.14 %	61.32
8	6g	68. 26%	114.24
9	6h	72. 39 %	124.61

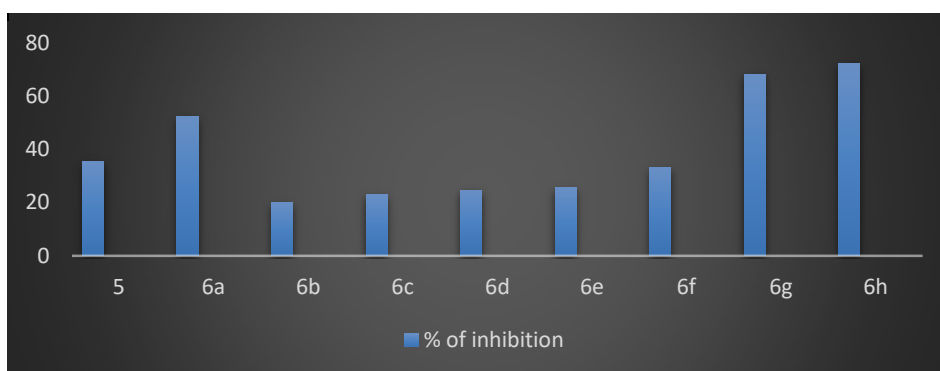


Fig. 3. Antitumor activity

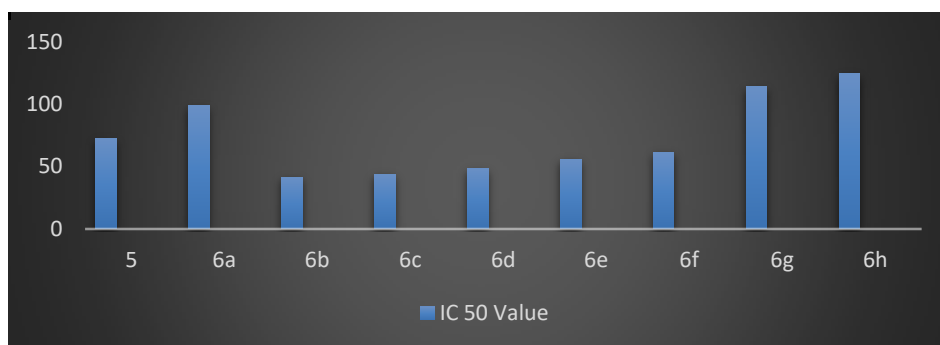


Fig. 4. IC 50 Value of compounds 5 & 6(a-h)

Table 4. Physical data of compounds 6 (a-h)

Compound	Molecular formula	Structure	Molecular weight	M.P (°C)	Yield (%)
6a	C ₁₇ H ₁₆ N ₄ OS		324.10	238-240	91
6b	C ₁₉ H ₁₈ N ₄ O ₂		334.14	250-252	93

Compound	Molecular formula	Structure	Molecular weight	M.P (°C)	Yield (%)
6c	C ₁₇ H ₁₆ N ₄ O ₂		308.13	241-243	85
6d	C ₁₉ H ₁₇ ClN ₄ O		352.82	247-248	87
6e	C ₁₉ H ₁₈ N ₄ O		318.38	210-212	81
6f	C ₂₂ H ₂₄ N ₄ O ₄		408.18	280-282	88
6g	C ₁₉ H ₁₇ N ₅ O ₃		363.38	239-240	83
6h	C ₁₉ H ₁₇ N ₅ O ₃		363.38	242-243	82

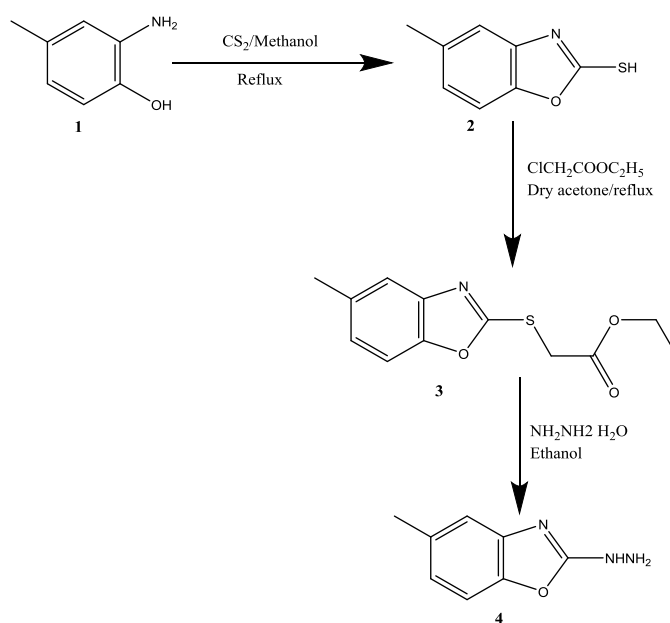


Fig. 5. Synthetic route for the synthesis of Compound 4

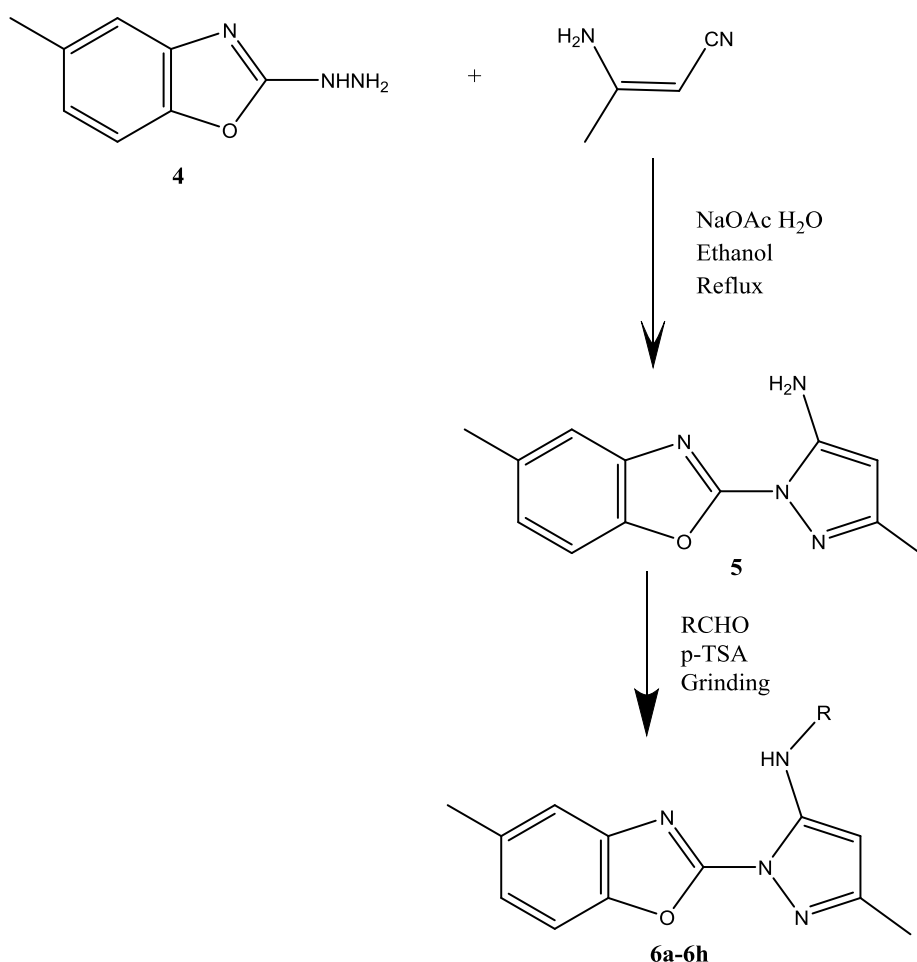


Fig. 6. Synthetic route for the synthesis of Compounds 6(a-h)

3. RESULTS AND DISCUSSION

3.1 Chemistry

Eight 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine derivatives were prepared from solvent free reductive amination reaction with selected aromatic aldehydes. The compound 2-hydrazinyl-5-methyl-1,3-benzoxazole 1 was prepared [14], further the target molecules 6(a-h) were synthesized using the intermediate 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine 2. The compound 1 was treated with 3-aminocrotonitrile (0.503 g, 0.006 mol, 1eq) was carried out in refluxing ethanol (50 mL) in the presence of sodium acetate monohydrate (0.50g, 0.006 mol, 1eq) to get the intermediate compound 2. It is characterized by IR, ¹H NMR and Mass analysis.

“The compound 2 was treated with different aldehydes to get target molecules 6a-6h and

confirmed by spectral analysis. The compound 2 was reacted with NaBH₄/p-TSA to form respective compounds 6a and 6h. In the ¹H NMR of 6a, the disappearance of -NH₂ proton and appearance of -NH supported the formation of product. The mass peak of compounds 6a shows at M+ 324 and for compound 6b M+ 334 which is matching with their molecular weights. The construction of compounds 6(a-h) followed a similar method of preparation” [20].

3.2 Biological Activity

The compounds 6(a-h) were screened for antibacterial and antitumor. In the antibacterial study, the compounds have shown inhibition of tested bacteria (Table 1). Among the synthesized compounds 6a, 6g and 6h showed very high zone of inhibition, while less activity was observed to the compounds 6e. The compound

6h is very good compound having potential of both antitumor and antibacterial activity and 6g and 6a exhibited promising antitumor activity.

4. CONCLUSION

This overall study reports the synthesis of different compounds via solvent free methods in good yield. The effective features of this method are mild reaction condition, and a wide variety of functional groups can be allowed. The target molecules were characterized and confirmed by mass, IR, ¹H NMR and ¹³C NMR analysis and screened for antitumor and antibacterial activities. Compound 6h is very good compound have potential of both antitumor and antibacterial activity and compound 6g and 6a are also having promising activity and compounds 6f and 6e are next to that, so the derivatives of 3-methyl-1-(5-methyl-1,3-benzoxazol-2-yl)-1H-pyrazol-5-amine were found to be biologically potent heterocyclic compound. This result could be utilized for the design of another antibacterial and antitumor agents with easy preparation.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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