

## Synthesis and *in vitro* biological activity of *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives

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A series of novel *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives, **4(a-f)** were synthesized by the reaction of *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine with various ketones in order to determine their *in vitro* antimicrobial activities against clinically isolated strains. The antioxidant activity was also determined by diphenylpicrylhydrazyl (DPPH) radical scavenging assay method. The chemical structures were confirmed by elemental analyses, UV-Vis, FT-IR and <sup>1</sup>H NMR spectral studies. The synthesized compounds **4b**, **4c** and **4e** showed moderate antimicrobial activity compared to standard drugs against bacterial and fungal strains tested. The compounds, **4b** and **4c** showed good antioxidant activity in diphenylpicrylhydrazyl (DPPH) radical-scavenging assay method.

**Key words:** *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine, ketones, antimicrobials, antioxidant.

### INTRODUCTION

Diseases caused by microbial infection are a serious menace to the health of human beings and often have connection to some other diseases, whenever the body system gets debilitated. Developing antimicrobial drugs and maintaining their potency, in opposition to resistance by different classes of microorganisms as well as a broad spectrum of antibacterial activity are some of the major concern of research in this area. The compounds containing an azomethine group (-C=N-) are important in elucidating the mechanism of transamination and racemisation reactions in biological systems [1, 2]. Due to the great flexibility and diverse structural aspects, a wide range of Schiff bases have been synthesized and their complexation behaviors have been studied [3]. They have been synthesized from a variety of compounds such as amino thiazoles, 2-hydroxy-1-naphthalaniline, amino sugars, aromatic aldehydes, acetophenones, isatin, triazole ring, thiosemicarbazides, amino acids, pyrazolone, etc [4, 5]. Antibacterial, antifungal, antitumor and anticancer activities of some Schiff bases have been reported and they are active against a wide range of organisms [6, 7]. Antibacterial activity has been studied more than antifungal activity, because bacteria can achieve resistance to antibiotics

through biochemical and morphological modifications [8, 9]. Some Schiff bases bearing aryl groups or heterocyclic residues possess excellent biological activities have attracted the attention of many researchers in recent years [10-12].

The Schiff bases formed from aromatic aldehydes or aromatic ketones and their derivatives are quite stable. Many Schiff bases are known to be medicinally important and are used to design medicinal compounds [6, 13]. In recent years there has been an increased interest in the application of antioxidants to medical treatment. Information is constantly gathered linking the development of human diseases to oxidative stress. Free radicals play a role in the pathogenesis of chronic degenerative diseases including cancer, autoimmune, inflammatory, cardiovascular and neurodegenerative diseases and aging generally [14-17]. It is also known that oxidative stress can be induced by a wide range of environmental factors including UV stress, pathogen invasion, pesticide action and oxygen shortage [18]. Owing to these facts, synthetic and natural compounds with potential antioxidation activity are receiving increased attention in biological research, medicine and pharmacy [19, 20].

*N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine is an intermediate for the preparation of imatinib which is an anti-cancer agent, and it is currently marketed as Gleevec. It has also been found to be effective in the treatment of gastrointestinal stromal tumors (GISTs) [21]. This selective inhibition of Bcr-Abl kinase by

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imatinib has been a successful therapeutic strategy for chronic myeloid leukemia because of the high efficacy and mild side effects of this compound [22]. In connection with such studies, the present paper reports for the first time on the synthesis of *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives, **4(a-f)** which are formed during the reaction of *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) with different ketones, **3(a-f)**. The synthesized compounds are characterized by elemental analyses and spectroscopy (UV-visible, FT-IR, <sup>1</sup>H NMR and <sup>13</sup>C NMR). Antimicrobial and antioxidant activities of compounds are reported and structural activity relationship is also discussed. On the basis of their activity, these derivatives are identified as viable for further studies.

## CHEMISTRY

The target key intermediate, *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) was synthesized according to the reported procedure [23] by reacting with stannous chloride dihydrate (11.29 g, 50 mmol) in hydrochloric acid (30 ml) and cooled at 0 °C. *N*-(2-methyl-5-nitrophenyl)-4-pyridin-3-yl-pyrimidin-2-ylamine (**1**, 3.69 g, 12 mmol) was added in portions while the suspension was vigorously stirred for 6 h. The mixture was then poured onto crushed ice, made alkaline with solid sodium hydroxide and extracted three times with ethyl acetate (100 ml). The combined organic phase was dried over anhydrous sodium sulphate and the filtrate was evaporated to dryness *in vacuo*. The residue was recrystallized from methanol.

## EXPERIMENTAL

### Materials and Methods

All solvents and reagents were purchased from Sigma Aldrich Chemicals Pvt Ltd. Melting range was determined by Veego Melting Point VMP III apparatus. Elemental analyses were recorded in DMSO on VarioMICRO superuser V1.3.2 Elementar. The UV-visible spectra were recorded on Analytikjena Specord 50 UV-Vis spectrophotometer with quartz cell of 1.0 cm path length. The FT-IR spectra were recorded using KBr discs on FT-IR Jasco 4100 infrared spectrophotometer and were quoted in cm<sup>-1</sup>. NMR spectra were recorded on Bruker DMX 300 spectrometer (300 MHz for <sup>1</sup>H NMR and 100 MHz for <sup>13</sup>C NMR) using DMSO-d<sub>6</sub> as solvent and TMS as an internal standard.

### General procedure for the synthesis of *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives, **4(a-f)**

Equimolar concentrations of different ketones, **3(a-f)** (0.01 mol) and *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**, 0.01 mol) were stirred for 6-8 hr at room temperature using absolute ethanol (25 ml) and then 2-3 drops of concentrated sulfuric acid was added to the mixture. The progress of the reaction was followed by TLC until the reaction was complete. It was cooled to 0°C, the precipitate was filtered, washed with diethyl ether and the residue was recrystallized from ethanol.

### 4-Methyl-*N*<sup>1</sup>-(1-phenylethylidene)-*N*<sup>3</sup>-(4-(pyridin-3-yl)pyrimidin-2-yl)benzene-1,3-diamine (**4a**)

The general experimental procedure described above afforded **4a**, and the product obtained from *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) (2.78 g, 0.01 mol) and acetophenone (**3a**) (1.21 g, 0.01 mol). FT-IR  $\nu$ : 3179 (N-H), 3955 (Ar-H), 1619 (C=N), 1558 (C=C), 1078 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.67 (s, 1H, pyr-H), 9.23 (s, 1H, N-H), 8.91 (d, 1H, J = 3.4 Hz, pyr-H), 8.70 (d, 1H, J = 5.3 Hz, pyrimidine-H), 8.53 (d, 2H, J = 7.2 Hz, Ar-H), 7.54-7.51(m, 3H, Ar-H), 7.44 (d, 1H, J = 3.9 Hz, pyr-H), 7.33 (t, 1H, J = 7.3 Hz, pyr-H), 7.25 (d, 1H, J = 6.1 Hz, pyrimidine-H), 6.98 (d, 1H, J = 6.0 Hz, Ar-H), 6.95 (d, 1H, J = 8.8 Hz, Ar-H), 6.31 (s, 1H, Ar-H), 3.84 (s, 3H, CH<sub>3</sub>), 2.49 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>24</sub>H<sub>21</sub>N<sub>5</sub> (in %): C-75.97, H-5.58, N-18.46. Found C-75.71, H-5.60, N-18.21.

### *N*<sup>1</sup>-(1-(1H-indol-3-yl)ethylidene)-4-methyl-*N*<sup>3</sup>-(4-(pyridin-3-yl)pyrimidin-2-yl)benzene-1,3-diamine (**4b**)

The general experimental procedure described above afforded **4b**, and the product obtained from *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) (2.78 g, 0.01 mol) and 1-(1H-indol-3-yl)ethanone (**3b**) (1.60 g, 0.01 mol). FT-IR  $\nu$ : 3181 (N-H), 3056 (Ar-H), 1628 (C=N), 1573 (C=C), 1077 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.68 (s, 1H, pyr-H), 9.30 (s, 1H, N-H), 9.21 (s, 1H, N-H), 8.90 (d, 1H, J = 3.1 Hz, pyr-H), 8.71 (d, 1H, J = 5.5 Hz, pyrimidine-H), 7.54-7.50 (m, 4H, Ar-H), 7.45 (d, 1H, J = 4.0 Hz, pyr-H), 7.33 (t, 1H, J = 7.1 Hz, pyr-H), 7.25 (d, 1H, J = 5.8 Hz, pyrimidine-H), 6.98

(d, 1H, J = 5.7 Hz, Ar-H), 6.94 (d, 1H, J = 7.6 Hz, Ar-H), 6.31 (s, 1H, Ar-H), 6.05 (s, 1H, pyrrole-H), 3.85 (s, 3H, CH<sub>3</sub>), 2.5 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>26</sub>H<sub>22</sub>N<sub>6</sub> (in %): C-74.62, H-5.30, N-20.08. Found C-74.81, H-5.50, N-20.21.

**4-Methyl-N<sup>1</sup>-(1-(pyridin-3-yl)ethylidene)-N<sup>3</sup>-(4-(pyridin-3-yl)pyrimidin-2-yl)benzene-1,3-diamine (4c)**

The general experimental procedure described above afforded **4c**, and the product obtained from N-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) (2.78 g, 0.01 mol) and 1-(pyridin-3-yl)ethanone (**3c**) (1.22 g, 0.01 mol). FT-IR  $\nu$ : 3181 (N-H), 3056 (Ar-H), 1689 (C=N), 1574 (C=C), 1078 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.61 (s, 1H, pyr-H), 9.30 (s, 1H, N-H), 9.20 (s, 1H, pyr-H), 8.72 (d, 1H, J = 2.8 Hz, pyr-H), 8.67 (d, 1H, J = 3.1 Hz, pyr-H), 7.44 (d, 1H, J = 5.0 Hz, pyrimidine-H), 7.31 (d, 1H, J = 3.8 Hz, pyr-H), 7.24 (d, 1H, J = 3.5 Hz, pyr-H), 7.13 (t, 1H, J = 7.0 Hz, pyr-H), 7.08-7.06 (t, 1H, J = 7.3 Hz, pyr-H), 7.01 (d, 1H, J = 6.1 Hz, pyrimidine-H), 6.96 (d, 1H, J = 5.9 Hz, Ar-H), 6.87 (d, 1H, J = 7.2 Hz, Ar-H), 6.30 (s, 1H, Ar-H), 3.85 (s, 3H, CH<sub>3</sub>), 2.5 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>23</sub>H<sub>20</sub>N<sub>6</sub> (in %): C-72.61, H-5.30, N-22.09. Found C-72.42, H-5.23, N-22.21.

**4-Methyl-N<sup>1</sup>-(1-(naphthalen-2-yl)ethylidene)-N<sup>3</sup>-(4-(pyridin-3-yl)pyrimidin-2-yl)benzene-1,3-diamine (4d)**

The general experimental procedure described above afforded **4d**, and the product obtained from N-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) (2.78 g, 0.01 mol) and 1-(naphthalen-2-yl)ethanone (**3d**) (1.71 g, 0.01 mol). FT-IR  $\nu$ : 3180 (N-H), 3057 (Ar-H), 1646 (C=N), 1572 (C=C), 1077 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.65 (s, 1H, pyr-H), 9.23 (s, 1H, N-H), 8.71 (d, 1H, J = 3.2 Hz, pyr-H), 8.58 (s, 1H, Ar-H), 8.53 (d, 1H, J = 7.3 Hz, Ar-H), 8.42 (d, 1H, J = 4.7 Hz, Ar-H), 7.54 (d, 1H, J = 5.1 Hz, pyrimidine-H), 7.43-7.4 (m, 4H, Ar-H), 7.38 (d, 1H, J = 3.4 Hz, pyr-H), 7.33 (t, 1H, J = 7.2 Hz, pyr-H), 7.25 (d, 1H, J = 6.4 Hz, pyrimidine-H), 6.98 (d, 1H, J = 5.7 Hz, Ar-H), 6.95 (d, 1H, J = 7.9 Hz, Ar-H), 6.31 (s, 1H, Ar-H), 3.85 (s, 3H, CH<sub>3</sub>), 2.45 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>28</sub>H<sub>23</sub>N<sub>5</sub> (in %): C-78.30, H-5.40, N-16.31. Found C-78.12, H-5.21, N-16.11.

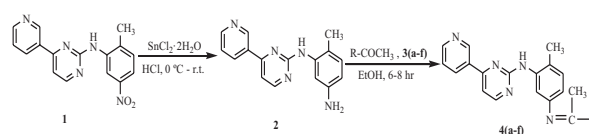
**4-Methyl-N<sup>3</sup>-(4-(pyridin-3-yl)pyrimidin-2-yl)-N<sup>1</sup>-(1-(pyridin-4-yl)ethylidene)benzene-1,3-diamine (4e)**

The general experimental procedure described above afforded **4e**, and the product obtained from N-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-

pyrimidinamine (**2**) (2.78 g, 0.01 mol) and 1-(pyridin-4-yl)ethanone (**3e**) (1.22 g, 0.01 mol). FT-IR  $\nu$ : 3189 (N-H), 3056 (Ar-H), 1698 (C=N), 1572 (C=C), 1078 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.60 (s, 1H, pyr-H), 9.31 (s, 1H, N-H), 8.72 (d, 2H, J = 7.2 Hz, pyr-H), 8.67 (d, 1H, J = 3.0 Hz, pyr-H), 8.54 (d, 2H, J = 6.8 Hz, pyr-H), 7.45 (d, 1H, J = 5.3 Hz, pyrimidine-H), 7.31 (d, 1H, J = 3.1 Hz, pyr-H), 7.15 (t, 1H, J = 7.7 Hz, pyr-H), 7.05 (d, 1H, J = 6.2 Hz, pyrimidine-H), 6.95 (d, 1H, J = 5.3 Hz, Ar-H), 6.87 (d, 1H, J = 7.1 Hz, Ar-H), 6.31 (s, 1H, Ar-H), 3.84 (s, 3H, CH<sub>3</sub>), 2.5 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>23</sub>H<sub>20</sub>N<sub>6</sub> (in %): C-72.61, H-5.30, N-22.09. Found C-72.82, H-5.01, N-22.28.

**3-(1-(3-(4-(Pyridin-3-yl)pyrimidin-2-ylamino)-4-methylphenylimino)ethyl)benzonitrile (4f)**

The general experimental procedure described above afforded **4f**, and the product obtained from N-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) (2.78 g, 0.01 mol) and 3-acetylbenzonitrile (**3f**) (1.46 g, 0.01 mol). FT-IR  $\nu$ : 3168 (N-H), 3056 (Ar-H), 2243 (C≡N), 1689 (C=N), 1574 (C=C), 1079 (C-N). <sup>1</sup>H NMR  $\delta$ : 9.67 (s, 1H, pyr-H), 9.21 (s, 1H, N-H), 8.71 (d, 1H, J = 3.3 Hz, pyr-H), 8.53 (d, 1H, J = 7.1 Hz, Ar-H), 7.43 (d, 1H, J = 5.2 Hz, pyrimidine-H), 7.35 (s, 1H, Ar-H), 7.54 (d, 1H, J = 4.5 Hz, Ar-H), 7.51 (d, 1H, J = 7.1 Hz, Ar-H), 7.45 (d, 1H, J = 3.4 Hz, pyr-H), 7.33 (t, 1H, J = 7.1 Hz, pyr-H), 7.25 (d, 1H, J = 6.3 Hz, pyrimidine-H), 6.97 (d, 1H, J = 5.1 Hz, Ar-H), 6.95 (d, 1H, J = 7.3 Hz, Ar-H), 6.32 (s, 1H, Ar-H), 3.85 (s, 3H, CH<sub>3</sub>), 2.46 (s, 3H, CH<sub>3</sub>). Anal. Calcd. for C<sub>25</sub>H<sub>20</sub>N<sub>6</sub> (in %): C-74.24, H-4.98, N-20.78. Found C-74.13, H-4.81, N-20.51.



Scheme 1

## ANTIBACTERIAL ASSAY

Antibacterial activity of the synthesized compounds was determined against Gram-positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*) and Gram-negative bacteria (*Xanthomonas malvacearum* and *Escherichia coli*) in DMF by disc diffusion method on nutrient agar medium [24]. The sterile medium (Nutrient Agar medium, 15 ml) in each Petri plates was uniformly smeared with cultures of Gram-positive and Gram-negative bacteria. Sterile discs of 6 mm diameter (Hi-Media) were made in each of the Petri plates, to which 50  $\mu$ L (concentration was 1 mg/ml, i.e., 50  $\mu$ g/disc) of

the different synthesized compounds were added. The treatments also included 50 µl of DMF and streptomycin as negative and positive control for comparison. Each compound was assessed in triplicate. The plates were incubated overnight at 25 ± 2 °C and then the inhibition zones were measured in millimeters.

#### ANTIFUNGAL ASSAY

The synthesized compounds were screened for their antifungal activity against *Fusarium oxysporum* and *Aspergillus niger* in DMF by poisoned food technique [25]. Potato Dextrose Agar (PDA) media was prepared and about 15 ml of PDA was poured into each petri plate and allowed to solidify. 5 mm disc of seven days old culture of the test fungi was placed at the center of the petri plates and incubated at 26 °C for 7 days. After incubation the percentage inhibition was measured, and three replicates were maintained for each treatment. Activity of each compound was compared with standard drugs. All of the synthesized compounds were tested (at the dosage of 500 µl of the novel compounds in Petri plate, where concentration was 0.1 mg/ml) by poisoned food technique.

#### DPPH RADICAL SCAVENGING ASSAY

The free radical scavenging activity of the synthesized compounds was studied *in vitro* by 1, 1-diphenyl-2-picrylhydrazyl (DPPH) assay method [26]. Stock solution of the drug was diluted to different concentrations in the range of 100–200 µg/ml in methanol. Methanolic solution of the synthesized compounds (2 ml) was added to 0.003% (w/v) methanol solution of DPPH (1 ml). The mixture was shaken vigorously and allowed to stand for 30 min. Then absorbance at 517 nm was determined and the percentage of scavenging activity was calculated. Ascorbic acid was used as a reference compound. All tests and analyses were done in duplicate and the results were averaged. The inhibition ratio (*I* %) of the tested compounds was calculated according to the following equation:

$$I\% = (A_c - A_s) / A_c \times 100$$


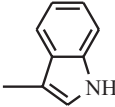

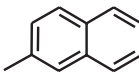

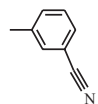
where *A<sub>c</sub>* is the absorbance of the control and *A<sub>s</sub>* is the absorbance of the sample.

#### RESULTS AND DISCUSSION

In this work, the novel N-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives **4(a–f)** were synthesized by the method summarized in Scheme 1. Compounds were purified by recrystallization using ethanol. The

chemical structures and physical data of all the synthesized compounds are tabulated in Table 1.

**Table 1.** Chemical structure of the synthesized compounds

| Compound | R  | Yield (%) | M.P. (°C) | UV-visible ( $\lambda_{max}$ ) |
|----------|--|-----------|-----------|--------------------------------|
| 4a       |  | 74        | 128-130   | 480                            |
| 4b       |  | 71        | 154-156   | 495                            |
| 4c       |  | 68        | 158-160   | 505                            |
| 4d       |  | 68        | 151-153   | 498                            |
| 4e       |  | 72        | 159-161   | 507                            |
| 4f       |  | 70        | 152-154   | 510                            |

The elemental analyses data showed good agreement between the experimentally determined values and the theoretically calculated values within the limits of permissible error. The synthesized compounds are stable in air, soluble in DMSO and DMF. The elemental analyses data confirm the stoichiometry and hence the molecular formula of the synthesized compounds. The electronic absorption spectra of synthesized compounds show new bands and appearance of longer wavelength absorption band in the visible region in UV-visible spectrum owing to confirms the formation of synthesized compounds.

The absence of NH<sub>2</sub> and C=O absorption bands in the IR spectra confirmed that the synthesized compounds **4(a–f)** were obtained via condensation. However the changes in integral intensities and band widths, especially of the bands originating from NH<sub>2</sub> stretching vibrations didn't show in products. The absorptions around 3000 cm<sup>-1</sup> in compounds **4(a–f)** confirm the aromatic C-H stretching vibrations, and the appearance of a medium to strong absorption bands above 1600 cm<sup>-1</sup> due to a stretching vibration of the azomethine (C=N) bond formation in synthesized compounds.

The proton spectral data agree with respect to the number of protons and their chemical shifts with the proposed structures. The proton spectral data agree with respect to the number of protons and their chemical shifts with the proposed structures. The proton spectral data of the

intermediate, *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine (**2**) shows resonance at  $\delta$  5.52 ppm (s, 2H, -NH<sub>2</sub>). In all the synthesized compounds **4** (a-f) the above resonances disappeared and additional resonances were observed, which confirmed the condensation between the amino group and carbonyl group.

To provide further evidence for the synthesized compounds, <sup>13</sup>C NMR spectra were recorded. The peaks at 164.23 - 164.01 ppm due to azomethine carbon atoms, which were not present in the starting materials. The strong signals at  $\delta$  151.04 - 108.32 ppm indicate the presence of aromatic carbons.

The antibacterial activity of compounds **4**(a-f) were evaluated and compared with streptomycin as standard drug. The compounds **4b**, **4c** and **4e** have shown moderate antibacterial activity against four pathogenic bacterial strains among the six compounds screened. Compared with streptomycin the compound **4f** showed less inhibitory activity against *B. subtilis* and *S. aureus*. Among the compounds **2** and **4**(a-f) the antibacterial inhibitory activity follows the order **4b** > **4e** > **4c** > **4d** > **4a** > **4f** > **2** against tested four pathogenic bacterial strains.

The antifungal activity of compounds **4**(a-f) were evaluated and compared with nystatin as standard. All the compounds do not show antifungal activity against *A. niger*. The compound **4b** showed moderate activity against *F. oxysporum*. Compared with nystatin the compounds **4c** and **4e** showed moderate inhibitory activity against *F. oxysporum*. It is evident from the results that most of the compounds are moderately active and few are weakly active. Among the compounds **2** and **4**(a-f) showed inhibitory activity in the order **4b** > **4e** > **4c** > **4d** > **4a** > **4f** > **2** against *F. oxysporum*. Antimicrobial screening results of the tested compounds are shown in Table 2.

Antioxidant activity results of the tested compounds are shown in Table 3. As antioxidants donate protons to DPPH radicals, the absorption decreases. The decrease in absorption is taken as a measure of the extent of radical scavenging. Free radical scavenging capacities of the compounds, measured by DPPH assay, are shown in Figure 1. Compound, **2** showed weak antioxidant activity (48.7 %) compared to standard ascorbic acid (99.3 %) at 200  $\mu$ g/ml. Compounds **4b** and **4c** showed good antioxidant activity (68.5 % and 63.7 %) at

**Table 2.** Antibacterial and antifungal activities of compounds

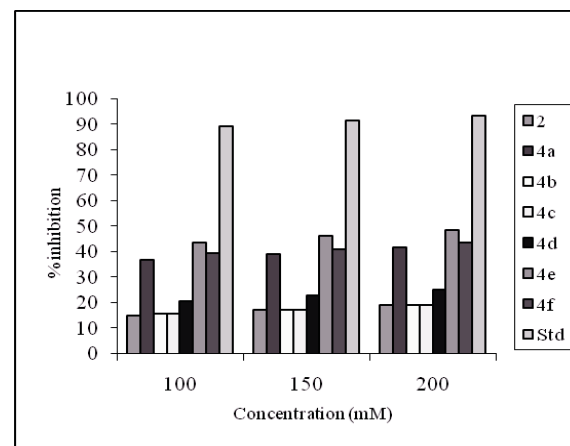
| Compound     | Zone of inhibition in diameter (mm) |                  |                       |                |                     | % inhibition |
|--------------|-------------------------------------|------------------|-----------------------|----------------|---------------------|--------------|
|              | <i>B. subtilis</i>                  | <i>S. aureus</i> | <i>X. malvacearum</i> | <i>E. coli</i> | <i>F. oxysporum</i> |              |
| <b>2</b>     | -                                   | -                | -                     | -              | -                   | 24.5         |
| <b>4a</b>    | 10                                  | 09               | -                     | -              | -                   | 38.2         |
| <b>4b</b>    | 11                                  | 11               | 08                    | 09             | -                   | 55.7         |
| <b>4c</b>    | 11                                  | 11               | 08                    | 08             | -                   | 47.6         |
| <b>4d</b>    | 10                                  | 09               | -                     | -              | -                   | 41.2         |
| <b>4e</b>    | 11                                  | 11               | 08                    | 09             | -                   | 54.1         |
| <b>4f</b>    | 09                                  | 08               | -                     | -              | -                   | 29.8         |
| Streptomycin | 18                                  | 21               | 13                    | 14             | -                   | -            |
| Nystatin     | -                                   | -                | -                     | -              | -                   | 90           |

- Denotes very low antibacterial activity (Zone of inhibition < 7 mm)

**Table 3.** Results of DPPH radical scavenging assay

| Compound      | Scavenging effect, (%) |                |                | IC <sub>50</sub> ( $\mu$ g/ml) |
|---------------|------------------------|----------------|----------------|--------------------------------|
|               |                        |                |                |                                |
|               | 100 $\mu$ g/ml         | 150 $\mu$ g/ml | 200 $\mu$ g/ml |                                |
| <b>2</b>      | 28.4                   | 39.3           | 48.7           | -                              |
| <b>4a</b>     | 30.8                   | 40.1           | 49.2           | -                              |
| <b>4b</b>     | 46.8                   | 56.4           | 68.5           | 114                            |
| <b>4c</b>     | 42.7                   | 53.1           | 63.7           | 134                            |
| <b>4d</b>     | 34.5                   | 42.7           | 51.0           | 196                            |
| <b>4e</b>     | 39.8                   | 46.4           | 53.3           | 180                            |
| <b>4f</b>     | 37.1                   | 44.6           | 52.5           | 185                            |
| Ascorbic acid | 74.1                   | 86.4           | 99.3           | 8.6                            |

No IC<sub>50</sub> value even at higher concentration i.e., at 200  $\mu$ g/ml



**Fig. 1** DPPH scavenging activity of different concentrations of compounds, **2** and **4**(a-f).

200  $\mu$ g/ml. The increased DPPH radical scavenging activity of all the newly synthesized compounds is as follows: **4b** > **4c** > **4e** > **4f** > **4d** > **4a** > **2**.

## CONCLUSION

In conclusion, a series of novel *N*-(5-amino-2-methylphenyl)-4-(3-pyridyl)-2-pyrimidinamine derivatives **4**(a-f) were synthesized in good yield, characterized by different spectral studies and their antimicrobial and antioxidant activities have been

evaluated. Compounds **4b**, **4c** and **4e** demonstrated moderate inhibition against bacterial and fungal strains tested. The antioxidant activity revealed that compounds **4b** and **4c** are good antioxidant activity. On the basis of their activity, these derivatives were identified as viable for further studies.

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#### СИНТЕЗ И *IN VITRO* БИОЛОГИЧНА АКТИВНОСТ НА N-(5-АМИНО-2-МЕТИЛФЕНИЛ)-4-(3-ПИРИДИЛ)-2-ПИРАМИДИНАМИНОВИ ПРОИЗВОДНИ

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(Резюме)

Серия от нови N-(5-амино-2-метилфенил)-4-(3-пиридил)-2-пиримидинаминови производни, **4(a-f)** са синтезирани чрез реакция на N-(5-амино-2-метилфенил)-4-(3-пиридил)-2-пиримидинамин с различни кетони, за да се определи тяхната *in vitro* антимикробна активност срещу клинично изолирани щамове. Антиоксидантната активност също се определя чрез анализ по метода на улавяне на свободните радикали дифенилпикрилхидразил (DPPH) Химическите структури са потвърдени от елементарен анализ, UV-Vis, FT-IR и <sup>1</sup>H NMR спектрални изследвания. Синтезираните съединения, **4b**, **4c** и **4d** показват умерена антимикробна активност в сравнение със стандартните лекарства, тествани срещу бактериални и гъбични щамове. Съединенията **4b** и **4c** показват добра антиоксидантна активност при изпитване по метода на улавяне на свободните радикали дифенилпикрилхидразил (DPPH).