Physico-chemical, Spectral, and Antimicrobial Evaluation of Novel substituted benzaldehydes derivatives of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine

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ABSTRACT

Novel substituted benzaldehyde derivatives of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine bearing a biologically active azomethine moiety were synthesised, characterised (solubility, stability, melting points), spectral studied (PMR, UV, and FT-IR spectra), and tested for antimicrobial activity. The antibacterial and antifungal activities of the synthesised compounds were demonstrated by MIC values varying from 50 to 250 g/mL. *Staphylococcus aureus* MCC 2010 was the most resistant, while *Escherichia coli* MCC 2412 and *Pseudomonas aeruginosa* MCC 2080 were the most susceptible. The antimicrobial screening results revealed that all tested compounds have considerable activity, with some being more active than the reference drugs used. (*streptomycin* and *fluconazole*).

Keywords: 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine, Azomethine, Antimicrobial screening, Antifungal activities

1. Introduction:

The important class of natural and synthetic products known as nitrogen heterocycles, many of which have beneficial biological properties, is particularly important. A wide range of biological activities, including antimicrobial [1], anti-inflammatory [2], and anti-tumour [3] activities, are displayed by pyrazoles and their variants. Chemists and biologists have recently focused on studying pyrazole derivatives due to the increasing number of applications for their synthesis and bioactivity. Pyrimidines are compounds with the pyrimidine ring system that have been found to have antibacterial [4], antifungal [5], antimalarial [6], anticonvulsant [7], and antitumor [8] properties. Pyrimidines are of chemical and pharmacological importance. Additionally, compounds comprising pyrrole and pyrrolopyrimidines were discovered to have various biological properties, including antimicrobial activity [9–13]. However, azomethine and its various derivatives are widely used in medicine owing to their pharmacological characteristics, such as antibacterial activity [14, 15]. Given these facts, this paper focuses on the synthesis of novel substituted benzaldehyde derivatives of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine bearing a biologically active azomethine moiety, where the nitrogen of the azomethine group is substituted by thiazole, pyrimidine, or quinoxaline moieties due to their well-documented antimicrobial activity [17–20].

2. Experimental

2.1. Experimental Design:

2.1.1. Chemistry

The melting points were found using an uncorrected S Lab Junction Melting Point and Boiling Point Apparatus. Elemental analysis (C, H, and N) was carried out at the microanalytical labs of Pune University using the Carlo Erba 1108 Elemental Analyzer. Every compound was within 0.4% of its expected value. The infrared readings (KBr) were obtained using a BRUKER IR 100 spectrophotometer. 1H NMR spectra were collected using a Bruker 400 MHz analyser with DMSO-d_6 as the solvent and tetramethylsilane (TMS) as the internal standard. Methanol solvent was used to record UV spectra on a JASCO V650 spectrophotometer at room temperature. All reactions were observed using thin-layer chromatography (TLC) with pre-coated aluminium sheets, Merck 60 F254 silica gel, and a UV lamp.

2.2. Substituted benzaldehyde derivatives of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine (1a-1k):

Refluxed in ethanol for 3–7 hours was a mixture of pyrrolo[2,3-d]pyrimidinehydrazide (**1**) (0.01 mol) and substituted benzaldehydes (**a–k**) (0.01 mol). The obtained substance was filtered and crystallised from methanol to yield **1a–1k**.

3.2.1. (*E*)-1-(2-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1a):

Yield % 82.37, m.p. 169 ^{o}C, IR: υ_{max}/cm^{-1}, 3381 (-NH- aromatic), 3187 (-CH=), 1588/1383 (>C=C<), 1528 (>C=N-), 1055 (-N-N-), 739 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.91 (s, 1H, NH, aromatic), 8.48 (s, 1H, -CH=), 8.05 (s, 1H, pyrimidine-H), 7.55-7.61 (m, 6H, aromatic-H). Anal. Calcd. for $C_{13}H_9N_4Cl_2$ (256.69): C, 60.83; H, 3.53; N, 21.83; Cl, 13.81. Found: C, 60.09; H, 3.51; N, 21.72; Cl, 13.69.

3.2.2. (*E*)-1-(3-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1b).

Yield % 86.99, m.p. 170 ^{o}C, IR: υ_{max}/cm^{-1}, 3374 (-NH- aromatic), 3125 (-CH=), 1589/1480 (>C=C<), 1527 (>C=N-), 1050 (-N-N-), 655 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 13.01 (s, 1H, NH, aromatic), 8.77 (s, 1H, -CH=), 8.05 (s, 1H, pyrimidine-H), 7.27-7.55 (m, 6H, aromatic-H). Anal. Calcd. for $C_{13}H_9N_4Cl_2$ (256.69): C, 60.83; H, 3.53; N, 21.83; Cl, 13.81. Found: C, 60.45; H, 3.49; N, 21.78; Cl, 13.72.

3.2.3. (*E*)-1-(4-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1c).

Yield % 80.99, m.p. 172 ^{o}C, IR: υ_{max}/cm^{-1}, 3378 (-NH- aromatic), 3179 (-CH=), 1582/1380 (>C=C<), 1527 (>C=N-), 1049 (-N-N-), 736 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.92 (s, 1H, NH, aromatic), 8.49 (s, 1H, -CH=), 8.07 (s, 1H, pyrimidine-H), 7.58-7.62 (m, 6H, aromatic-H). Anal. Calcd. for $C_{13}H_9N_4Cl_2$ (256.69): C, 60.83; H, 3.53; N, 21.83; Cl, 13.81. Found: C, 60.56; H, 3.55; N, 21.70; Cl, 13.75.

3.2.4. (*E*)-1-(2-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1d).

Yield % 78.47, m.p. 173 ^{o}C, IR: υ_{max}/cm^{-1}, 3370 (-NH- aromatic), 3119 (-OCH_3), 2832 (-CH=), 1586/1421 (>C=C<), 1521 (>C=N-), 1033 (-N-N-), 736 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.98 (s, 1H, NH, aromatic), 8.73 (s, 1H, -CH=), 8.46 (s, 1H, pyrimidine-H), 7.09-8.01 (m, 6H, aromatic-H), 3.87 (s, 3H, -OCH_3). Anal. Calcd. for $C_{14}H_{12}N_4O$ (252.27): C, 66.65; H, 4.79; N, 22.21; O, 6.34. Found: C, 66.38; H, 4.59; N, 22.12; O, 6.29.

3.2.5. (*E*)-1-(3-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1e).

Yield % 82.55, m.p. 171 ^{o}C, IR: υ_{max}/cm^{-1}, 3384 (-NH- aromatic), 3181 (-OCH_3), 2831 (-CH=), 1585/1422 (>C=C<), 1522 (>C=N-), 1033 (-N-N-), 736 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.98 (s, 1H, NH, aromatic), 8.75 (s, 1H, -CH=), 8.46 (s, 1H, pyrimidine-H), 7.06-8.00 (m, 6H, aromatic-H), 4.05 (s, 3H, -OCH_3). Anal. Calcd. for $C_{14}H_{12}N_4O$ (252.27): C, 66.65; H, 4.79; N, 22.21; O, 6.34. Found: C, 66.51; H, 4.72; N, 22.19; O, 6.31.

3.2.6. (*E*)-1-(4-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine (1f).

Yield % 86.72, m.p. 175 ^{o}C, IR: υ_{max}/cm^{-1}, 3381 (-NH- aromatic), 3178 (-OCH_3), 3078 (-CH=), 1584/1458 (>C=C<), 1524 (>C=N-), 1020 (-N-N-), 763 (di sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 13.03 (s, 1H, NH, aromatic), 8.78 (s, 1H, -CH=), 8.52 (s, 1H, pyrimidine-H), 7.12-7.72 (m, 6H, aromatic-H), 3.91 (s, 3H, -OCH_3). Anal. Calcd. for $C_{14}H_{12}N_4O$ (252.27): C, 66.65; H, 4.79; N, 22.21; O, 6.34. Found: C, 66.60; H, 4.76; N, 22.20; O, 6.32.

3.2.7. 3-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,2-diol (1g).

Yield % 79.54, m.p. 179 ^{o}C, IR: υ_{max}/cm^{-1}, 3525 (Ar -OH, C2), 3515 (Ar -OH, C3), 3355 (-NH- aromatic), 2873 (-CH=), 1587/1472 (>C=C<), 1528 (>C=N-), 1022 (-N-N-), 723 (tri sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.96 (s, 1H, NH, aromatic), 9.66 (s, 1H, -OH, C2), 9.03 (s, 1H, -OH, C3), 9.03 (s, 1H, -CH=), 8.43 (s, 1H, pyrimidine-H), 6.74-7.65 (m, 5H, aromatic-H). Anal. Calcd. for $C_{13}H_{10}N_4O_2$ (254.24): C, 61.41; H, 3.96; N, 22.04; O, 12.59. Found: C, 61.32; H, 3.93; N, 22.01; O, 12.52.

3.2.8. 4-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,3-diol (1h).

Yield % 81.79, m.p. 176 ^{o}C, IR: υ_{max}/cm^{-1}, 3513 (Ar -OH, C2), 3310 (Ar -OH, C4), 3190 (-NH- aromatic), 2880 (-CH=), 1595/1447 (>C=C<), 1529 (>C=N-), 974 (-N-N-), 718 (tri sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.93 (s, 1H, NH, aromatic), 10.29 (s, 1H, -OH, C2), 10.18 (s, 1H, -OH, C4), 8.92 (s, 1H, -CH=), 8.42 (s, 1H, pyrimidine-H), 6.41-8.06 (m, 5H, aromatic-H). Anal. Calcd. for $C_{13}H_{10}N_4O_2$ (254.24): C, 61.41; H, 3.96; N, 22.04; O, 12.59. Found: C, 61.30; H, 3.95; N, 22.00; O, 12.51.

3.2.9. 2-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,4-diol (1i).

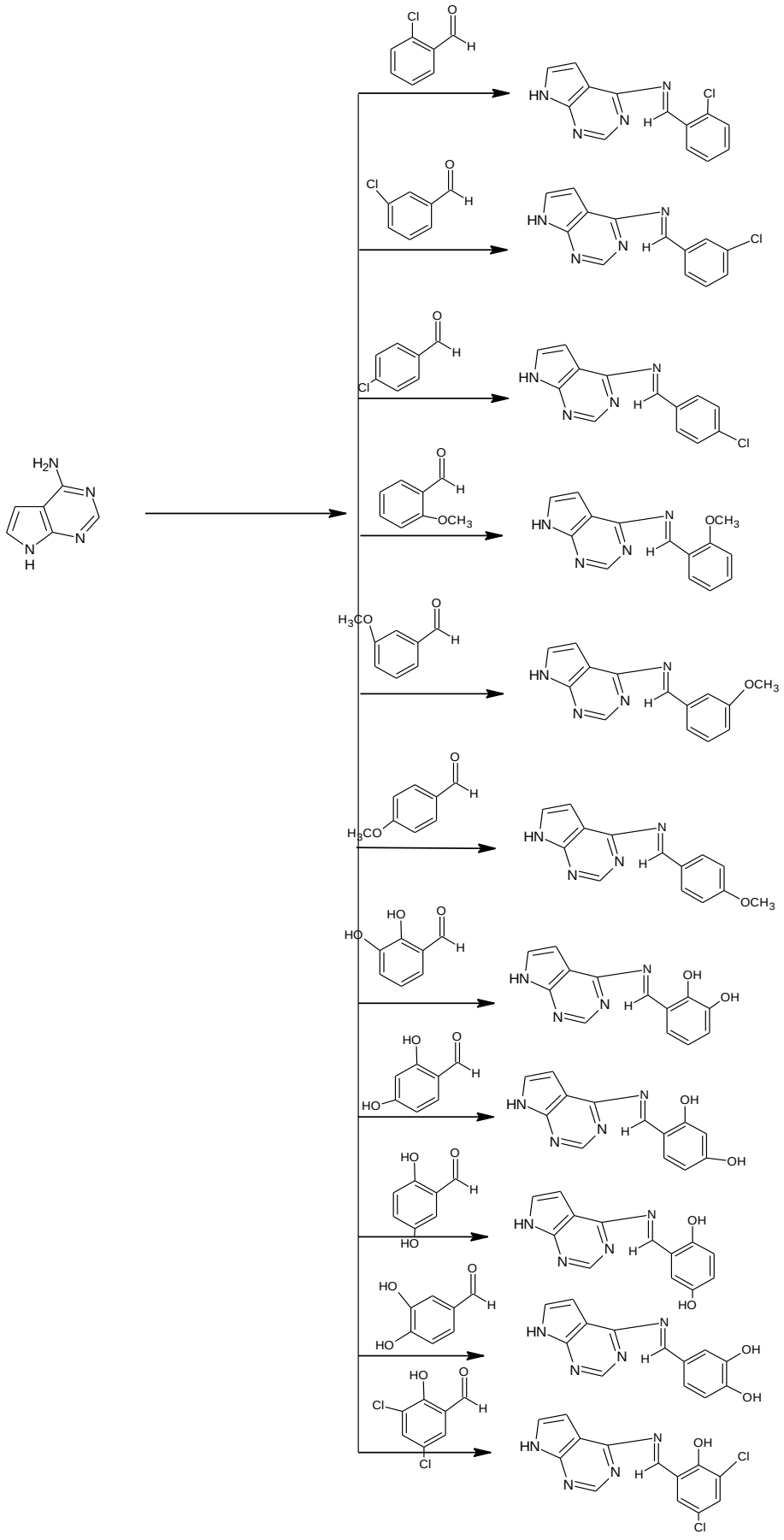
Yield % 71.99, m.p. 170 ^{o}C, IR: υ_{max}/cm^{-1}, 3511 (Ar -OH, C2), 3349 (Ar -OH, C5), 3188 (-NH- aromatic), 2897 (-CH=), 1594/1458 (>C=C<), 1529 (>C=N-), 1022 (-N-N-), 736 (tri sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.99 (s, 1H, NH, aromatic), 9.72 (s, 1H, -OH, C2), 9.00 (s, 1H, -OH, C5), 8.44 (s, 1H, -CH=), 7.55 (s, 1H, pyrimidine-H), 6.87-7.26 (m, 6H, aromatic-H). Anal. Calcd. for $C_{13}H_{10}N_4O_2$ (254.24): C, 61.41; H, 3.96; N, 22.04; O, 12.59. Found: C, 61.36; H, 3.90; N, 22.01; O, 12.44.

3.2.10. 4-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,2-diol (1j).

Yield % 79.46, m.p. 175 ^{o}C, IR: υ_{max}/cm^{-1}, 3515 (Ar -OH, C2), 3350 (Ar -OH, C4), 3383 (-NH- aromatic), 2995 (-CH=), 1650/1472 (>C=C<), 1528 (>C=N-), 1019 (-N-N-), 775 (tri sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.96 (s, 1H, NH, aromatic), 9.86 (s, 1H, -OH, C2), 9.30 (s, 1H, -OH, C4), 9.03 (s, 1H, -CH=), 8.42 (s, 1H, pyrimidine-H), 6.74-7.65 (m, 6H, aromatic-H). Anal. Calcd. for $C_{13}H_{10}N_4O_2$ (254.24): C, 61.41; H, 3.96; N, 22.04; O, 12.59. Found: C, 61.37; H, 3.91; N, 21.96; O, 12.53.

3.2.11. 2,4-dichloro-6-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]phenol (1k).

Yield % 80.56, m.p. 181 ^{o}C, IR: υ_{max}/cm^{-1}, 3594 (Ar -OH), 3190 (-NH- aromatic), 3065 (-CH=), 1590/1451 (>C=C<), 1529 (>C=N-), 1022 (-N-N-), 732 (tetra sub benzene ring). ^{1}H-NMR (DMSO-d_6) δ: 12.52 (s, 1H, NH, aromatic), 8.70 (s, 1H, -OH), 8.41 (s, 1H, -CH=), 7.99 (s, 1H, pyrimidine-H), 6.95-7.62 (m, 4H, aromatic-H). Anal. Calcd. for $C_{13}H_8N_4OCl_2$ (307.13): C, 50.84; H, 2.63; N, 18.24; O, 5.51; Cl, 23.09. Found: C, 50.78; H, 2.55; N, 18.20; O, 5.49; Cl, 23.01.



Scheme-1. Synthetic pathways for compounds (**1a-1k**)

3.3. Antimicrobial evaluation

Different specimens (clinical isolates) of fungi and bacteria and synthesised compounds acquired in pure dry powder form were used. *S. cerevisiae* MCC1033 and *Candida albicans* MCC1439 were among the fungal strains. The mould isolates were kept in sterile water and subcultured on antimicrobial agent-free potato dextrose agar to guarantee viability and purity. Gram-positive bacteria included *Staphylococcus aureus* MCC 2010 and *Bacillus subtilis* MCC 2010, as well as Gram-negative bugs *Escherichia coli* MCC 2412 and Pseudomonas aeruginosa MCC 2080. The organisms were acquired from the National Centre for Molecular Research in Pune, India.

The compounds were dissolved in dimethyl formamide (DMF), which had no inhibitory impact on the microorganisms at the concentrations examined and was kept at 4°C. For bacteria, nutrient broth (NB; Difco) and nutrient agar (NA) are used, while for fungus, potato dextrose agar and Sabaouraud liquid medium are used.

3.3.1. Antibacterial screening

The antimicrobial activity of the synthesised substances was evaluated using two gram-positive bacteria (*Staphylococcus aureus* MCC 2010 and *Bacillus subtilis* MCC 2010) and two gram-negative bacteria. (*Escherichia coli* MCC 2412 and *Pseudomonas aeruginosa* MCC 2080). Muller Hilton agar medium was used for antimicrobial testing, and it was autoclaved at 15 lbs/in2 for 15 minutes. The disc diffusion method assessed the antimicrobial activity of newly synthesised compounds [21]. The inoculum size was reduced to approximately 108 colony-forming units (cfu/mL) to evaluate antimicrobial activity by suspending the culture in sterile distilled water. The appropriate microbial strain cultures were swabbed into Petri dishes holding 20 mL of Muller Hilton agar medium to allow for culture absorption. The 100 litres of each compound's 4.0 mg/mL solution, reconstituted in DMSO, were added to the pre-inoculated plates, and the wells (6 mm in diameter) were produced using a clean borer. Each plate was incubated for 24 hours at 37 °C. Each plate was incubated for 24 hours at 37 °C. The zone of inhibition encircling the wells was used to assess the antimicrobial activity of all synthetic substances. *Streptomycin* was a positive control, and DMSO was a negative control [22].

3.3.2. Antifungal Activity

The cup-and-plate technique was used to test the chemicals' effectiveness against two fungi [16–17]. (Candida albicans MCC1439 and S. cerevisiae MCC1033). The test solution was injected into the 5 mm diameter and 1-millimetre thick discs using a micropipette. Following that, the dishes were held at 37 °C for 72 hours. During this time, the test solution spread and impacted the growth of the inoculated fungus. After 36 hours of incubation at 37 °C, the circumference of the inhibition was measured. Research on minimum inhibitory concentrations was done on substances with possible antifungal activity. The lowest concentration at which visible microbial development was inhibited after an overnight incubation was designated the minimum inhibitory concentration (MIC) of an antifungal substance. MIC was used in diagnostic labs to verify microorganism resistance to antimicrobial agents and check the effectiveness of new antimicrobial agents.

4. Results and Discussion:

The synthetic methods used to obtain the target molecules are depicted in **Scheme 1.** This research examined the interaction between substituted benzaldehydes and 7*H*-

pyrrolo[2,3-*d*]pyrimidin-4-amine**.** IUPAC names and abbreviations of prepared **a** to **k** compounds (*E*)-1-(2-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1a),** (*E*)-1-(3-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1b)**, (*E*)-1-(4-chlorophenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1c)**, (*E*)-1-(2-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1d)**, (*E*)-1-(3-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1e)**, (*E*)-1-(3-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1f)**, (*E*)-1-(4-methoxyphenyl)-*N*-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-yl)methanimine **(1g)**, 3-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,2-diol **(1g),** 4-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,3-diol **(1h)**, 2-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,4-diol **(1i),** 4-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]benzene-1,2-diol **(1j)** and 2,4-dichloro-6-[(*E*)-(7*H*-pyrrolo[2,3-*d*]pyrimidin-4-ylimino)methyl]phenol **(1k)**. The methods used to synthesise the desired molecules are depicted in **Figure 1**. This research examined how substituted benzaldehydes reacted with 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine.

3.1. FT(IR) spectra:

It was feasible to analyse the bonding of the 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine to substituted benzaldehydes by comparing the FT(IR) spectra of the synthesised molecules with those of the free compound. The impact of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine vibration on modified benzaldehydes was studied using several prominent bands. The absence of stretching vibrations from the aldehyde (CHO) and amino (NH_2) moieties proves that all prepared molecules have developed as expected. Instead, a robust new band associated with the azomethine (HC=N-) group [23] formed in the 1439–1537 cm^{-1} range. Broadband designated as aromatic -NH- in the 3064–3391 cm^{-1} region suggests the existence of the prepared compounds [24–25]. All substances have been connected to the (-CH=) aldehydic bands between 2710 and 3092 cm^{-1}. Sharp lines can be seen in the IR spectra of **a-k** compounds at 1581–1589 and 1383–1453 cm^{-1}, connected to an aromatic ring's >C=C< group. Strong bands can be found in the 1318–1339 cm^{-1} and 689–776 cm^{-1}. The aromatic (C-N) ring and the di- or trisubstituted benzene ring can all be found in the FT(IR) bands of the **1a-1k** compounds.

3.2. ^{1}H NMR spectra:

The broad singlet signals seen at 12.919–13.029 ppm in the ^{1}H NMR spectra of all synthesised compounds are caused by the aromatic NH moiety in the pyrrole ring. The aldehydic -CH= group of all prepared chemicals is attributed to another singlet peak in the 8.653–8.995 ppm range, and the aliphatic NH singlet peak appears in the 13.931–14.387 ppm range. The fact that there is no broad singlet signature at 9.84 ppm (2H), which correlates to the -NH_2 of 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine, in the 1H NMR spectra of all of the synthesised derivatives, indicates that Schiff base [26] was successful in substituting the amino group. The 1H-NMR spectra of compounds a through **1i** show **1k** singlet for the pyrimidine proton at 8.444–8.513 ppm. All substances produced have singlet signals ranging from 3.190 to 4.050 ppm.

3.3. Antimicrobial evaluation:

The new compounds were tested in vitro for antibacterial and antifungal activity using the broth microdilution method against *Candida albicans* (MCC1439) and *Saccharomyces*

cerevisiae (MCC1033), as well as Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus* (MCC 2010), *Bacillus subtilis* (MCC 2010), *Escherichia coli* MCC 2412 and *Pseudomonas aeruginosa* (MCC 2080).

After being incubated for 24 hours at 37 °C, all bacterial isolates were grown in nutrient broth. The sabouraud dextrose agar was kept in malt broth after being incubated for 24 hours at 25 °C, and tween 80 was used to gather the suspensions of fungal spores from fungi that had been actively growing for 7 days. The final inoculum optical densities (OD) for bacteria and fungus were 0.2–0.3 and 0.5, respectively. The DMSO used to prepare the stock solutions does not affect the investigated concentrations. At a 1000 g/mL concentration, bacteria and fungi were multiplied by two. *Fluconazole* and *streptomycin* were common medication powders for pathogens and fungi. The antimicrobial activity was evaluated following 24 hours at 37 °C and 48 hours at 25 °C for the antifungal test.

3.3.1. Antibacterial activity:

Streptomycin, a broad-spectrum antibiotic with a 10 g/mL MIC against the bacterium species, served as the study's reference medication. The suppression zones for *Escherichia coli* (MCC 2412), *Bacillus subtilis* (MCC 2010), *Pseudomonas aeruginosa* (MCC 2080), and *Staphylococcus aureus* (MCC 2010) were 12–21 mm, 10–17 mm, 12-21mm and 9–16 mm, respectively. The antibacterial results in **Table 1** clearly showed that all the bacteria tested were susceptible to the tested compounds, with MICs varying from 50 to 250 g/mL.

Table 1: Antibacterial activities of **1a** to **1k** compounds

Compound	Antibacterial Activity (zone of inhibition)			
	S. aureus	***B. subtilis***	***E. coli***	***P. aeruginosa***
1a	12.00	15.00	17.00	16.00
1b	13.00	16.00	15.00	14.00
1c	15.00	17.00	16.00	18.00
1d	11.00	15.00	20.00	21.00
1e	16.00	15.00	21.00	17.00
1f	14.00	15.00	19.00	19.00
1g	13.00	14.00	20.00	20.00
1h	11.00	12.00	18.00	19.00
1i	12.00	13.00	17.00	17.00
1j	12.00	11.00	15.00	14.00
1k	9.00	10.00	12.00	12.00
Streptomycin	11.00	10.00	12.00	14.00

For each bacterial species, **1f** was the most potent for *S. aureus*. At the same time, the **1e** (26mm) was found to be more active than the standard drug. For *P. aeruginosa*, the reference drug was discovered to be less effective than **1d**. The most effective compounds against E. coli were discovered to be **1e**.

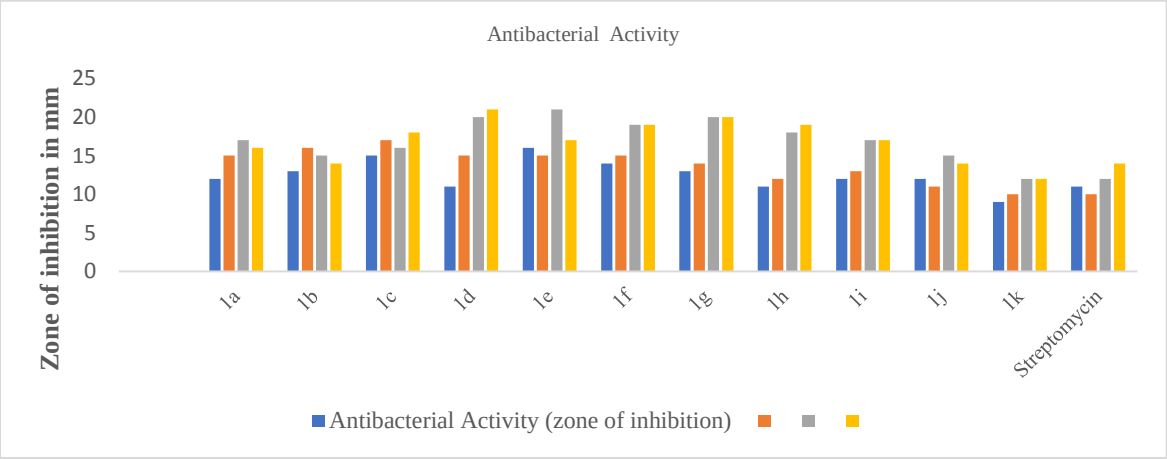


Figure 1: Antibacterial activities of **1a** to **1k** compounds

Concerning each bacterial species, the **1e** (21mm) was more active than the reference drug for *S. aureus*. At the same time, the **1g** was less effective for *P. aeruginosa*, and **1d** was more effective than the reference drug for *P. aeruginosa*. The (a), (b), and (c) were found to be the most effective against *E. coli*, while the **1d**, **1e**, and **1g** were effective against *B. subtilis*. The antimicrobial effect is most likely a result of microorganisms' less lipophilic cell walls, which make it simpler for them to enter cells. This is most likely because the molecule's lipophilic alkyl chain allows it to travel through the lipid cell membrane of gram-negative bacteria. The findings indicate that the antibacterial activity decreases as the length of the carbon chain increases. This might be because the molecule can't travel through the bacterial cell membrane due to the carbon chain's bulk [27].

3.3.2. Antifungal activity

Fluconazole was used as the standard drug in this research; its MIC for the tested fungi was 50 g/ml, and its inhibition zones for *Candida albicans* (MCC1439) and *Saccharomyces cerevisiae* (MCC1033) were 10–19 mm and 11–19 mm, respectively. With a MIC of 54 g/mL against *Candida albicans* (MCC1439) and *Saccharomyces cerevisiae* (MCC1033), which is more potent than the standard drug, all compounds tested from **Table 2** demonstrated high fungicidal potential.

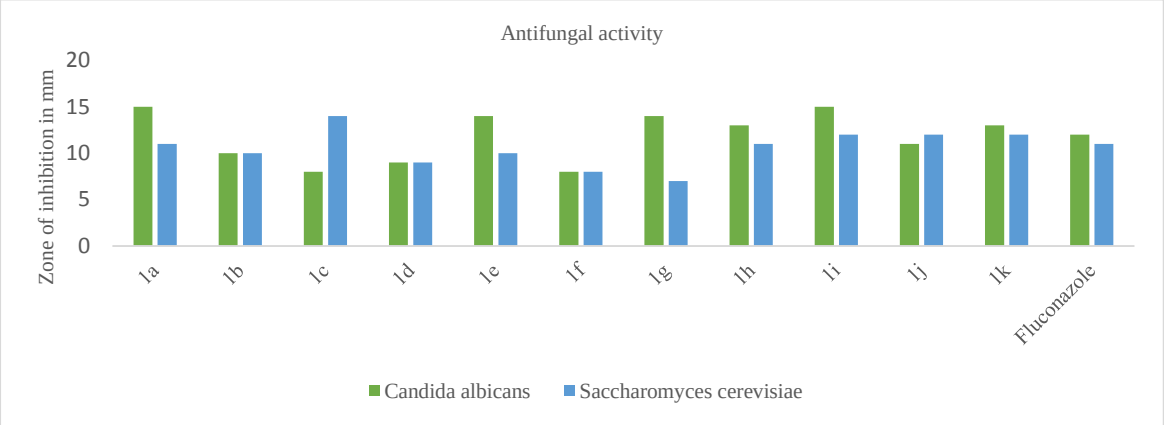


Figure 2: Antifungal activities of **1a** to **1k** compounds

Table 2: Antifungal studies of **1a** to **1k** compounds

Compound	*Candida albicans*	*Saccharomyces cerevisiae*
1a	15.00	11.00
1b	10.00	10.00
1c	8.00	14.00
1d	9.00	9.00
1e	14.00	10.00
1f	8.00	8.00
1g	14.00	7.00
1h	13.00	11.00
1i	15.00	12.00
1j	11.00	12.00
1k	13.00	12.00
Fluconazole	12.00	11.00

4. Conclusion

In this research, we have produced several brand-new substituted 7*H*-pyrrolo[2,3-*d*]pyrimidin-4-amine derivatives of aromatic benzaldehydes. The formation of the proposed compounds is confirmed by analytical data, FT-IR, UV-vis, NMR spectral investigations, and electrochemical data. The $^{1}H/^{13}C$ NMR, UV-vis, elemental analysis (C, H, N, O), and FT-IR spectra of the synthesized aromatic benzaldehyde-based molecules were recorded and investigated. The research recommends a 1:1 mixture of modified benzaldehydes and 7H-pyrrolo[2,3-d]pyrimidin-4-amine. All synthetic materials exhibited outstanding antibacterial activity.

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